DRAFT ENVIRONMENTAL REPORT

ON

CAPE VERDE

prepared by the

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Summary

Faced with recurrent drought and famine during five centuries of human occupation, the small and densely populated Cape Verde Islands have a history of severe environmental problems. The arid climate and steep, rocky terrain provide scant resources for traditional subsistance farming under the best conditions, and in years of low rainfall the failure of rainfed crops causes massive food shortages. Agricultural use of steep slopes where rainfall is highest has led to soil erosion, as has removal of the island's vegetation for fuel and livestock. Pressure on the vegetation is particularly severe in dry years.

International aid can provide relief from famine, and the introduction of modern agricultural and conservation techniques can improve the land and increase yield, but it is unlikely that Cape Verde can ever be entirely self-sufficient in food. Ultimately, the solution of Cape Verde's economic and environmental problems will probably require the development of productive urban jobs so the population can shift away from the intensive and destructive use of land for subsistance farming. In the meantime, the people of Cape Verde can best be served by instituting fundamental measures to conserve and restore the land so that it can be used to its fullest potential.

The primary environmental problems in Cape Verde today are:

1. Soil degradation. Encouraged by brief but heavy rains and steep slopes, soil erosion is made worse by lack of vegetation. Soils are also low in organic matter due to the practice of completely removing crop plants and natural vegetation for food, fuel or livestock feed.

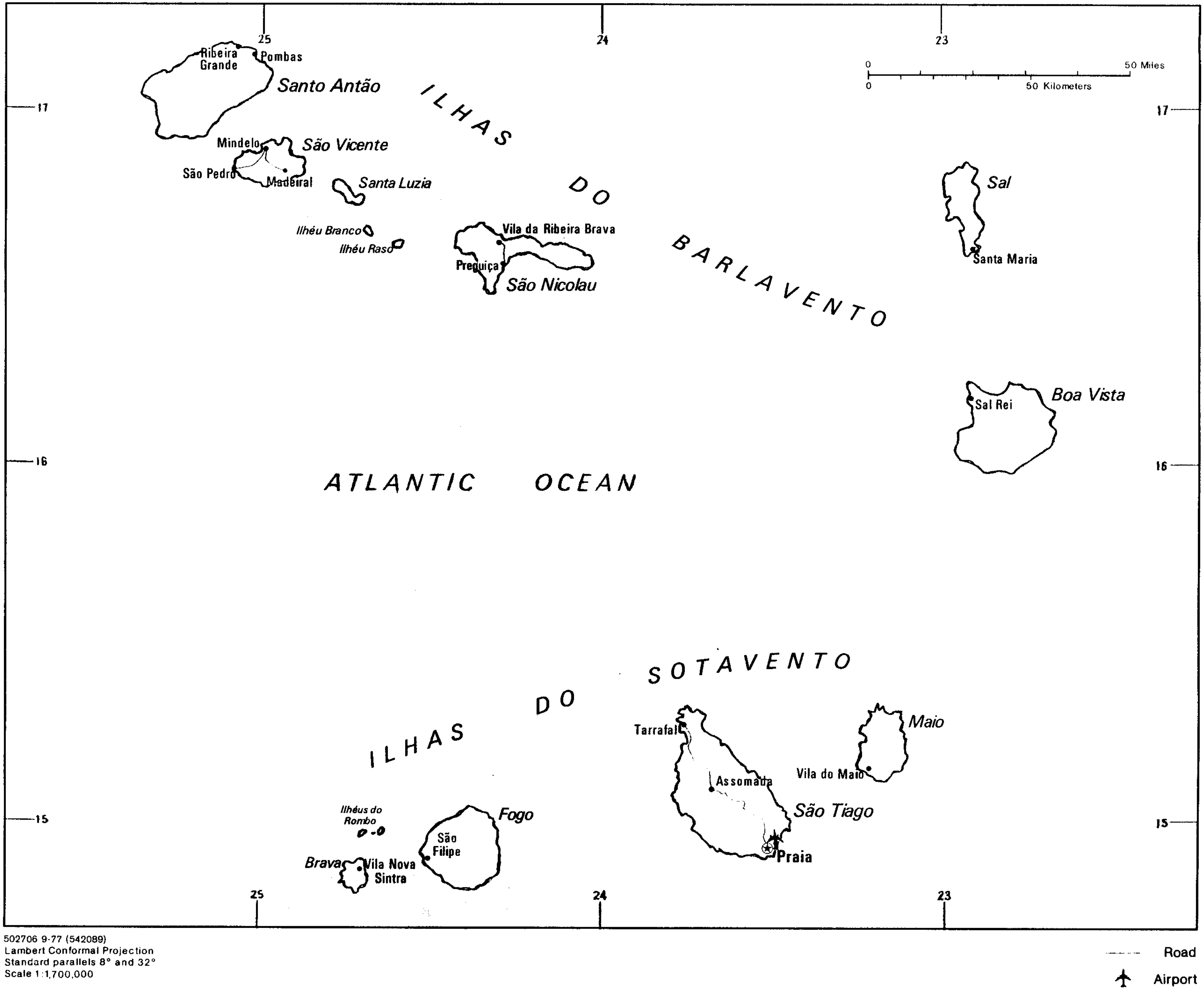
2. Water shortage. Brief and erratic rainfall in combination with rapid runoff makes surface water scarce and difficult to use. Groundwater supplies can be better developed but capabilities are poorly known and the complex nature of the geological substrate makes estimation difficult. Water is the critical limiting factor to the agricultural capability of the islands.

3. Fuel shortage. Demand for fuel is intense and has resulted in the virtual elimination of native vegetation. Fuelwood supplies are becoming more and more scarce and costly. Development of managed fuelwood plantations and alternate energy sources is required.

4. Inappropriate land use. Much of the land now used for raising crops or livestock is too steep or too arid for these purposes, causing erosion and destruction of vegetation. Improving yield in more appropriate areas and encouraging less damaging uses of the remaining marginal lands can help to alleviate this problem.

Dr. James R. Silliman
Compiler

Cape Verde



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1.0 Preface

This report will introduce the reader to the major environmental features of the Cape Verde Islands and point out existing environmental problems. It is a desk study only, based on the rather limited information available in the literature about the Cape Verde Islands. The primary source is the agriculture assessment prepared for U.S. AID by Freeman et al. for General Research Corporation in 1978, to which the reader should refer for further detail.

2.0 General Description [1]

2.1 Geography and Climate

2.1.1 General features

The Cape Verde Islands (Cabo Verde in Portuguese) are a group of 10 islands and 5 islets located in the Atlantic Ocean some 600 km (360 miles) west of mainland Africa and between about 15 and 17 degrees north latitude. Of volcanic origin, the archipelago includes one island (Fogo) with an active volcano which last erupted in 1951. The rocky and barren islands collectively include only 4000 sq km of land area, although they are spread over an extensive square section of ocean roughly 240 km on a side. The islands are traditionally divided into two groups, based on the prevailing northeast trade winds: the northern *Ilhas de Banlavento* (Windward Islands), composed of six major islands and 2 islets, and the southern *Ilhas de Sotavento* (Leeward Islands) composed of 4 major islands and 3 islets.

2.1.2 Rainfall

Cape Verde has an arid climate, being located at the western edge of the large arid and semi-arid belt which crosses North Africa. Both the regularity and amount of rainfall at particular localities on the islands depend strongly on elevation, as can be seen for Santiago (Fig. 1), where rainfall ranges from 1000 mm per year near the points of highest elevation to 300 mm per year or less throughout the low arid coastal plains. The coefficient of rainfall variability is relatively high everywhere (35-60 percent), with the highest variability in the lowest, most arid areas. There are no permanent streams or lakes anywhere in the archipelago.

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[1] Source: Amaral. 1964.
Barbosa in Bannerman and Bannerman. 1968.
Freeman et al. 1978.
Teixeira and Barbosa. 1958.

Most rain falls from July to October (Fig. 2), when the South Atlantic monsoon winds bring rainstorms from the west or southwest. During this period of erratic torrential rains, half the year's rainfall may occur in a single storm. For the remainder of the year, the islands are exposed to the generally drying effects of the northeast tradewinds and the occasional hot and dry harmattan winds from the east. The northeast tradewinds are humid, however, and condense to form mists from 400 to 1300 meters on the more mountainous islands.

2.1.3 Temperature

Temperatures are moderate throughout the islands and, like the rains, influenced by elevation. At Praia, Santiago, (elevation 27 meters) monthly means range from 22°C in February to 27°C in September. Temperatures at higher elevations are cooler by 5.5°C per 1000 meter increase in elevation, as well as less variable, with an annual range of only about 3°C in monthly means at intermediate elevations.

2.1.4 Variation among Islands

The considerable influence that variation in relief can have on the climates of different islands is partly illustrated by Table 1. The islands of Santiago, Santo Antao, Fogo, Sao Nicolau, and Brava all have elevations in excess of 300 meters, enough to generate orographic rainfall and provide irrigation water for agriculture. This is particularly true where large areas of high elevation are exposed to the prevailing northeast winds, as on Santiago. All five of these higher and wetter islands are also characterized by severe relief, with many steep-walled narrow canyons and craggy peaks. The remaining five islands are flatter and too dry to sustain more than minimal agriculture.

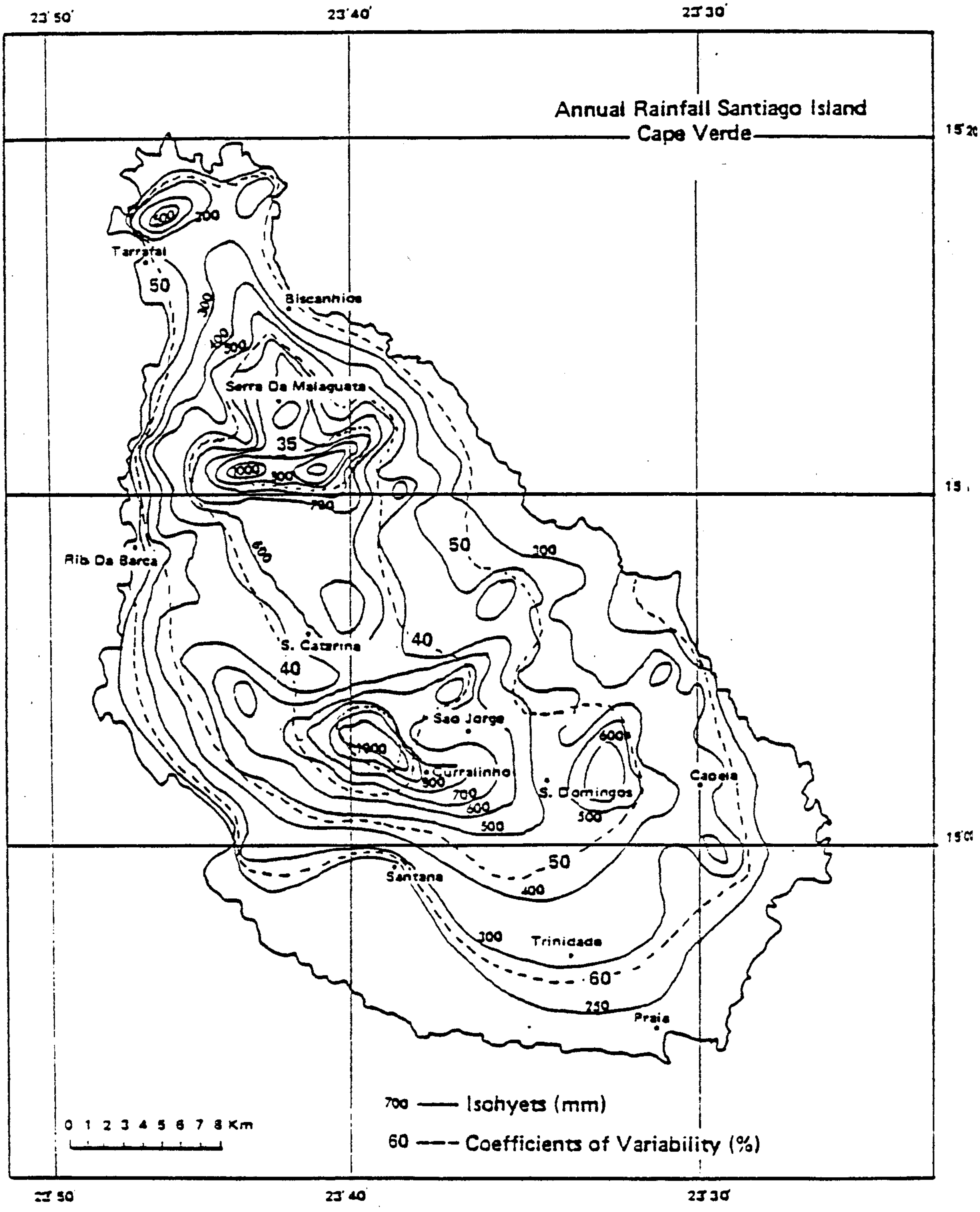
2.1.5 Winds and Humidity

Strong winds and high humidity are climatic constants on all the islands. At Praia, Santiago, north or northeast winds blow 78 percent of the time, with calms only seven percent of the time. At high elevations in mountain passes, it can be difficult to walk and maintain footing due to the force of the wind. Humidity stays high due to the moist northeast tradewinds. In ten years of observation at Praia, relative humidity rarely fell below 55 percent.

2.1.6 Periodic Drought

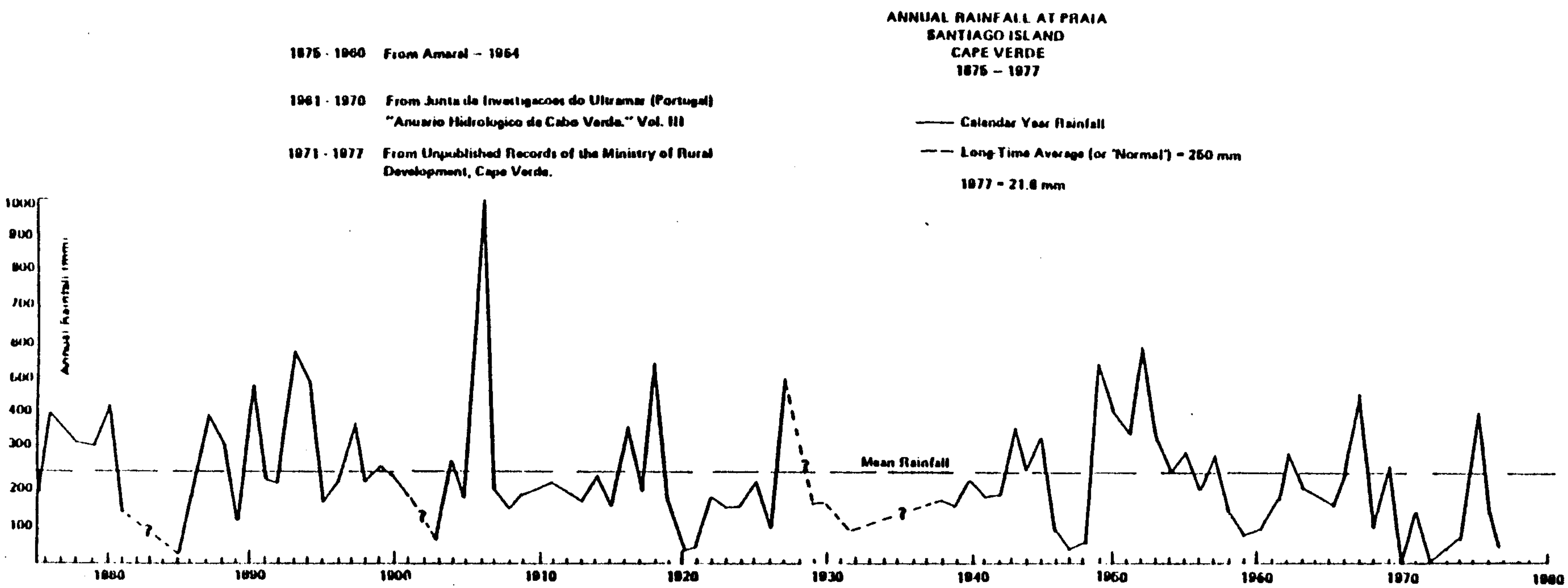
Cape Verde is currently experiencing a drought of twelve years duration, broken only by two years (1975 and 1978) with adequate rainfall. Periodic long-term droughts are a historical feature of the Cape Verde climate, having been marked in past centuries by records of famine (see Section 2.2) and documented for the last century by rainfall records at Praia (Fig. 2).

Figure 1. Annual Rainfall of Santiago Island



Source: Freeman et al. 1978.

Figure 2. Annual Rainfall Records for Praia, Santiago (elevation 27 M.)



Source: Freeman et al. 1978.

Table 1

	Area (sq km)	Population Estimates In 1977 (1000's)	Highest Elevation (M)	% Land used for agriculture
Santiago	992	144.0	1392	32.3
Santo Antao	754	47.5	1979	13.0
Boa Vista	622	4.0	387	0.8
Fogo	477	29.7	2829	29.9
Sao Nicolau	342	15.2	1304	4.2
Maio	267	4.0	436	3.1
Sao Vicente	228	44.1	725	0.7
Sal	215	6.8	406	0
Brava	65	6.6	976	8.5
Santa Luzia	34	0	395	0
Raso (islet)	7	0	164	0
Branco (islet)	3	0	327	0

Sources: Amaral. 1964.
Europa. 1980.
Freeman et al. 1978.

The cause of these recurrent droughts as well as the variability of annual rainfall distribution is the periodic shifting of the pattern of controlling ocean and wind currents. Atmospheric turbulence creates rain at the West African Inter-tropical Convergence (where the South Atlantic monsoon winds and northeast tradewinds meet), but Cape Verde lies slightly too far north of its seasonal path. Small shifts in the position of the Convergence thus have a profound effect on the Cape Verde climate and cause critical fluctuations in annual rainfall. Such fluctuations are particularly disastrous to the Cape Verdians, who intensify agriculture and increase livestock herds as well as their own population to suit a series of favorable rainfall years, only to suffer losses of human life and precious resources when the dry years inevitably, if unpredictably, arrive.

2.2 Population [2]

2.2.1 Cultural Background

The Cape Verde Islands were uninhabited when discovered by the Portuguese about 1460, and showed no signs of any previous human settlement. The early settlers were Europeans (Portuguese, Sephardic Jews, Italians, and Spaniards) who were encouraged by the Portuguese colonial government to bring African slaves from what is now Guinea-Bissau and Senegal to work on their plantations. Extensive racial intermarriage eventually produced a population which is today about 60-70 percent mixed Portuguese and African descent, 28 percent African, and one-to-two percent European. Portuguese colonial rule ended after more than 500 years in July 1975, when Cape Verde became an independent republic. Portuguese is the official language but Crioulo, a Portuguese/West African dialect, is the common spoken language. Most Cape Verdians are Roman Catholics (65 percent), but Protestant sects have also gained a following.

2.2.2 Population Size and Limits to Growth

The present population of the archipelago totals about 330,000, with an annual growth rate of 2.1 percent. This makes Cape Verde the most densely populated of any of the Sahelian countries, and creates a demand for food that cannot be met by local agricultural production, even with foreseeable technological improvements in production. Cape Verdians are currently forced to rely on international aid to avoid famine. The population of Cape Verde might even be greater were it not for historical episodes of famine and constant emigration. Prior to recent international support, recurrent severe drought caused disastrous famines, reducing the population by up to

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[2] Source: The Environmental Fund. 1979.
Europa. 1980.
Freeman et al. 1978.
Teixeira and Barbosa. 1958.
U.S. Office of Foreign Disaster Assistance. 1979.

40 percent at a time (Table 2). Cape Verdians, particularly young males, have traditionally emigrated from the islands during times of hardship (Table 3). It is estimated that some 700,000 people of Cape Verdian birth or descent currently reside outside the republic. Their remittances to Cape Verde are critical to the national economy; in 1976, such remittances amounted to U.S. $17.5 million, or almost half the trade deficit.

2.2.3 Local Variations in Population

Approximately 70 percent of the population lives in rural areas. The four islands of Santiago, Santo Antao, Fogo, and Sao Nicolau have 90 percent of the rural population, owing to their relatively favorable conditions for agriculture and large size. Rural population densities per sq km of agricultural land range from 810 on Sao Nicolau to 173 on Fogo.

The population of Santiago is further augmented by the urban population (23,000) at Praia, the national capitol, making Santiago the most populous island (Table 1). Other important centers of non-agricultural population are the major port of Mindelo on Sao Vicente (32,000), and the international airport and salt mining operation on Sal (6,150). During the drought years of 1968-1977, the islands of Sao Vicente and Sal had the highest population growth rates, owing to the failure of agriculture and the corresponding attraction of urban life. Sao Nicolau, on the other hand, which was hard-hit by the drought and is 87 percent rural, actually declined in population during this time, largely due to emigration.

2.2.4 Nutrition and Health

The diet of the rural poor in Cape Verde consists mostly of "cachupa", a dish made by boiling corn in water with salt and a little lard or oil. Beans, fish, or meet may be added if available. As a dietary staple, cachupa provides an inadequate supply of calories, low-quality protein, insufficient fats, and is insufficient in vitamin B2, leading to pellagra.

Malnutrition, poor sanitation, and overcrowding contribute to a variety of health problems in Cape Verde. Pellagra and anemia are common; marasmus and kwashiorkor have also been observed. Infant mortality rates, though lower than in the first part of the century, have remained at the relatively high figure of ten percent for two decades. The major causes are gastroenteritis (40 percent), childhood diseases such as chicken pox, measles, and diptheria (22 percent) and respiratory tract infections (10 percent). Heart disease is the single largest cause of adult mortality, particularly in women over 50.

Several diseases are found in the populations of particular islands. Malaria, thought to have been eradicated in the 1960's, has reappeared on Santiago where 50 cases a week were reported in 1978, most originating in the central region of the island. Leprosy is

Table 2. Major Drought-Caused Famines in the Past 200 Years

1774 - 1775 ....22,000 dead
1831 - 1833 ....12,000 dead (about 35% of population)
1863 - 1865 ....30,000 dead (about 40% of population)
1902 - 1904 ....15,000 dead (about 25% of population)
1920 - 1922 ....17,000 dead (about 20% of population)
1940 - 1941 ....30,000 dead (about 15% of population)

Source: U.S. Office of Foreign Disaster Assistance. 1978.

Table 3. Emigration from Cape Verde During the Last Century

Period	Total for the Decade	Mean Annual	Percent of Total Population
1900-1909	16,130	1,614	1.4
1910-1919	26,630	2,663	1.8
1920-1929	11,322	1,132	0.7
1930-1939	5,244	524	0.3
1940-1949	25,411	2,541	1.6
1950-1959	45,607	4,561	3.1
1960-1969	69,221	6,922	3.4
1970-1973	62,227	15,694	5.7

Source: Freeman et al. 1978.

Table 4. Population Density per Square Kilometer on Total and Agricultural Land

	All Land			Agricultural Land	
Island	1960	1970	1977	Total Population Density[a]	Rural Population Density[b]
(1)	(2)	(3)	(4)	(5)	(6)
Boa Vista	5.2	5.6	6.5	829.9	662.0
Brava	126.7	116.6	98.0	1,158.9	868.2
Fogo	53.7	62.4	62.4	208.6	173.4
Maio	9.8	12.8	15.0	488.7	331.7
Sal	12.0	26.1	31.4	---	---
Santiago	89.2	130.7	145.3	450.3	352.1
Santo Antão	43.3	57.8	60.9	467.4	392.6
São Nicolau	35.5	42.1	39.3	932.5	810.1
São Vicente	92.0	139.1	194.1	26,225.6	7,173.0
Total	49.4	67.6	74.8	502.7	336.3

[a] Density of the total population in 1977 on all agricultural land
[b] Density of the rural population on agricultural land

Source: Freeman et al. 1978.

most common on Fogo (18/1000 incidence) and Santo Antao (7.04/1000 incidence), and is found at very low levels (2/1000 incidence on Brava, Santiago and Sao Vicente. Hookworm is prevalent in Sao Nicolau, Santiago and Brava, and scattered cases of cholera were reported in 1974 on Sal, Sao Vicente, Santo Antao and Brava.

There are positive signs of improvement in the health of the general population. In recent years bronchitis and enteritic diseases have caused fewer deaths and there has been an overall decline in mortality rates. Medical aid and personnel supplied by other nations have improved the availability of health care considerably. Given the health consequences of overcrowding and malnutrition, a hopeful sign for the improved health of future generations is the recent acceptance of I.U.D.s and contraceptive pills among urban and rural women of Mindelo and Santo Antao, despite traditional emphasis on large families.

2.3 Land Use [3]

2.3.1 Background

From the time the islands were first settled by the Portuguese until the present, Cape Verde's land has been used to yield crops, food for livestock, and fuel. Owing to the small size of the islands, the arid climate, and the limited area suitable for agriculture, both land resources and natural vegetation have been exploited to the fullest extent. Land area used for both rainfed and irrigated crops has remained constant for many years, due to the restricted zone of adequate precipitation and minimal development of groundwater resources. Because intensity of land use in Cape Verde is dictated by rainfall and because fluctuations in amount of rainfall are large, the effects of drought on land use are severe. Rural people move to urban centers in dry years, livestock populations fall, and the area planted in both irrigated and rainfed crops is reduced.

2.3.2 Crops

In the early colonial period the Cape Verdian economy depended principally on the slave trade, but some cash crops were exported. Among these were cotton, grown on plantations on Santiago and Fogo, and wine from vineyards on Fogo, Santiago, Sao Nicolau, and Santo Antao. A wild lichen used to produce blue and purple dyes in Europe was also collected for export. Purgenuts, castor beans, bananas and coffee are more recent export crops, but changing markets, drought, and a competitive disadvantage have caused agricultural production to be dominated by subsistence crops for local consumption. These subsistence crops are largely corn and beans.

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[3] Source: Teixeira and Barbosa. 1958.
U.S. Office of Foreign Disaster Assistance. 1979.

Cape Verdian agricultural methods consist of simple manual methods of planting and harvesting. Improved crop varieties are not in general use, and although the ancient varieties still cultivated have low yields, they have developed some inherent resistence to insects, disease, and drought. Fertilizers and pesticides are only rarely used in Cape Verde.

The 41,787 hectares of cropland planted in optimal rainfall conditions (Table 5) are mostly used for rainfed crops (94 percent), with the remainder (six percent) under irrigation. If rainfall is poor, 80 percent of this cropland is not used (Table 5), with the major loss being to rainfed crops. Irrigated crops are also affected by drought, as springs dry up and irrigation water is applied less frequently and in smaller doses, just enough to keep plants alive.

Rainfed crops, mostly interplanted corn and beans (Table 5), are grown in semi-moist and semi-arid zones between 300-1000 meters on the windward slopes. Santiago has the largest area suited to rainfed agriculture and produces 70 percent of the crop. Santo Antao, Fogo and Sao Nicolau follow Santiago in the amount of available rainfed cropland; Boa Vista, Maio, and Brava have little or none, and neither Sal or Sao Vicente has ever supported rainfed farming (Table 6).

Irrigated crops, mostly sugar cane, cassava, and bananas (Table 5), are grown in canyons and valleys where springs, shallow wells, or fog condensation provide water. Crops may be planted in long strips directly along the canyon washes or *ribieras* but are subject to damage from flash floods. Another method is to use the steep lower slopes of valleys leading out of the floodplain, and these are terraced wherever sufficient water is available, even on slopes exceeding 100 percent. This practice produces some very narrow terraced fields, occasionally so narrow as to support only one row of sugar cane. Terrace walls in the Paul Valley of Santo Antao are used for planting cassava by inserting the plant through holes in the rock walls. Most irrigated lands are found on the northeast or windward sides of Santiago, Santo Antao, and, to a lesser extent, Sao Nicolau. The remaining islands do not have mountains sufficiently high or massive enough to capture and concentrate orographic rainfall.

2.3.3 Livestock

When the first colonists began living on the Cape Verde Islands over 500 years ago, they brought with them their livestock, especially goats, which were liberated on some islands even before humans settled. By 1490, Boa Vista had an established population of goats, and in 1510 the principal exports of the islands included goat skins, leather, tallow, and horses. The goat has remained the most popular livestock animal in the islands due to its ability to subsist in steep terrain on poor quality forage. It is also the right size to feed families without use of refrigeration. Most families also own a few pigs, some chickens or muscovy ducks, and guinea fowl. Horses, donkeys, and mules provide the main form of transportation in rural areas.

Table 5. Extent of Rainfed and Irrigated Crops under Optimal and Poor Rainfall Conditions.

	Optimal Conditions Area (Hectares)	%	Poor Conditions Area (Hectares)	%
Rainfed	39,287		6,287	
Corn and Beans		89		80
Sweet Potatoes		10		16
Coffee		1		4
Irrigated	2,500		1,852	
Sugarcane		?		57.5
Cassava and Sweet Potatoes		?		12.1
Bananas		?		3.7
Misc. Garden Crops and Fruit Trees		?		21.7
Total	41,787		8,139	

Source: Freeman, et al. 1978

Table 6. Estimated Potential Land Available for Agriculture. (Hectares).

Island	All Land	Agricultural[a] Total	Agricultural[a] Rainfed	Agricultural[a] Irrigated	Share of Agricultural Land in Total (2 ÷ 1)
(1)	(2)	(3)	(4)	(5)	(6)
Boa Vista	62,000	482	480	2	0.8
Brava	6,740	570	540	30	8.5
Fogo	47,600	14,237	14,231	6	29.9
Maio	26,900	823	806	17	3.1
Sal	21,600	---	---	---	0.0
Santiago	99,090	31,980	31,030	950	32.3
Santo Antão	77,900	10,157	9,357	800	13.0
São Nicolau	38,800	1,634	1,605	29	4.2
São Vicente	22,700	168	150	18	0.7
Total	403,330	60,051	58,199	1,852	14.9

a) Estimated potential land area available for agricultural use, not necessarily what is actually used.

Source: Freeman et al. 1978

Lands used in at least some capacity for grazing amount to 2250 sq. km. or 50 percent of the republic, but only about 541 sq. km. are actually managed for range or pasture (Table 7). Ten to twenty years ago, pastures and rangelands were in fair condition, but after years of drought they are parched, degraded, and devoid of suitable vegetation. No true pasture exists today in the islands. The practice of maintaining livestock numbers at the highest level possible is indicated by the effects of the recent drought. Animal populations developed to peak numbers at the end of the 1960s after several years of favorable rainfall and then declined drastically during the drought (Table 8). Range and pasture lands have suffered to the point that rural Cape Verdians now keep all of their animals, except some goats, restrained to prevent their entering irrigated gardens. Animals are fed crop byproducts such as corn and banana stalks, cane tops, bean stalks, tomato vines, or cut browse and forage gathered by hand. Some of this material is literally uprooted, then bundled and carried for miles to the animals. An additional consequence of prolonged overgrazing is the predominance of thorny, toxic, and distasteful plants in areas once used for range. International aid currently provides some feed as part of an emergency cattle feeding program.

2.3.4 Fuel

Fuel for both cooling and heating is in high demand and short supply in the Cape Verde Islands. The average consumption per day of firewood for a family is estimated at five kilograms of wood. Almost a third of the entire archipelago would have to be planted in mesquite (*Prosopis juliflora*) to supply the needs of the present population. Vegetative sources of fuel are scarce, and the consumption of costly imported butane and kerosene is climbing steeply. Cape Verdians currently uproot or trim woody shrubs (e.g. *Lantana*, *Dichrostachys*) for fuel, or use agricultural byproducts such as squeezed sugarcane stalks or dried corn stalks.

Table 7. Rangeland Area by Island, 1971.

	All Rangeland Area (Hectares)
Santiago	23,862
Fogo	16,105
Brava	1,895
Santo Antão	8,603
São Nicolau	2,203
Maio	433
Boa Vista	1,005
Total	54,106

Source: Freeman et al. 1978.

Table 8. Animal Numbers in Cape Verde, 1968 and 1977.

Year	Cows	Goats	Sheep	Pigs
1968	41,800	75,000	3,000	50,000
1977	17,000	65,000	1,900	27,000
% change	-59.3	-13.3	-36.7	-46.0

Source: Freeman et al. 1978.

3.0 Environmental Resources

3.1 Geology and Mineral Resources [4]

The Cape Verde Islands are for the most part exceptionally steep and rocky. Due to the relatively recent geological origins of the archipelago, the predominance of durable igneous and volcanic formations, and the scarceness of water, geological events rather than weathering or erosion have determined the character of the landscape. There are limited outcrops of old Jurrassic and Cretaceous limestones, but the vast majority of the formations are more recent volcanic deposits from the Tertiary era. About nine percent of surface outcrops are sedimentary, of which 90 percent are limestone; the remaining outcrops are of basaltic or phonolitic origin.

Virtually all types of landscapes associated with extrusive igneous or volcanic activity are to be found in the archipelago. At lower elevations, multiple thick layers of basalt underlie arid rocky plains, which drop 100 meters in places to rocky shores. Built on these basaltic pedestals are craggy peaks and ranges of more recent volcanic origins, between which lie plateaus built by basalt flows rather than filled in by erosion. Breccias, pumice, pillow lava and pozzolana are among the other volcanic forms found throughout the islands.

Windward slopes are generally steeper than leeward slopes for two reasons. First, rainfall is higher on the windward slopes of the more mountainous islands, and the increased water erosion creates steep slopes often exceeding 100 percent, steep stream gradients, and valleys that are deeply cut and choked with coarse colluvium as well as rocks and large boulders. Second, prevailing winds probably carried volcanic ash and other pyroclastics to leeward after eruptions. This is best seen by the asymetrical form of Fogo, basically a single volcano whose leeward side is of greater radius than the windward.

Fogo is notable for its enormous caldera formed when the top of the old volcano blew off, and for the new volcano which rises 1000 meters from the caldera floor, twice the size of Italy's Mt. Vesuvius. Elsewhere on Fogo smaller eruptions have formed numerous volcanic cones, and the most recent (1951) eruptions produced lava beds that have frozen on the mountainsides.

Calcareous rocks outcrop in places on Santiago and on the flatter and drier islands of Boa Vista and Maio. Dunes of calcareous sand on Sal, Boa Vista and Maio probably derive from coral reefs and reef flats. These islands have brilliant white sand, wide, curving beaches, and blue waters, in contrast to the coarse, black sand, boulders or basalt rocks which are most common along shorelines elsewhere in the islands.

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[4] Source: Europa. 1980.
Freeman, et al. 1978.
Mitchell-Thomé, R. C. undated.

The only commercial mining today is of salt and pozzolana, although coral was also exported in the 19th century. The salt and pozzolana industries are small scale, producing 789 tons of pozzolana and 13,701 tons of salt in 1976.

3.2 Soils [5/]

This section reveiws the general characteristics of soils throughout Cape Verde, based mostly on the information in Freeman et al. (1978). Information for particular islands ranges from detailed for Santiago (Hargreaves 1977), general for Fogo (Faria 1974), Boa Vista (Nunes 1968), and Sao Nicolau (Nunes 1962), to none at all for Santo Antao and others. Problems of soil erosion and soil conservation measures will be discussed in Section 4 of this report.

3.2.1 Origin of Soils

Soils of the Cape Verde Islands are almost entirely derived from volcanic or igneous rock, and much of the archipelago still consists of bare rock. Santiago is about 65 percent covered with soils, a high proportion of coverage for the islands. Fogo and Santo Antao have the most recent deposits of soil parent material in the form of volcanic ash and lava flows, which do not yet support vegetation.

Soils used for rainfed agriculture in the islands are brown to reddish-brown sandy or clayey loams which are derived from igneous rocks rich in calcium or limestone outcrops. These Isohumic soils are of alkaline to neutral pH and the calcium carbonate in them tends to form lime crusts and duricrusts which prohibit the passage of rainwater. They are shallow, coarse textured and stoney with limited ability to retain water, a condition which is aggravated by their low organic content. Accumulation of organic matter is inhibited by the practice of removing all possible vegetation for food, browse, and fuel during times of drought.

Irrigated soils are coarse alluvial and colluvial deposits in valley bottoms and along the footslopes of valleys. These soils are of varying depth and with every rain are replenished with materials eroded from catchments. Stream beds are so steep and runoff so fast in many places that finer sediments are flushed to the sea.

Some idea of the scarcity of good soils can be appreciated from Table 9 and Fig. 3. Note that Lithosols, which are very rocky with hardly any true soil, predominate on Fogo and Santiago (Table 9). These are recommended only for forestry or grazing. Isohumic soils, Andosols, alluvial deposits and volcanic deposits suitable for agri-

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[5]Source: Freeman et al. 1978.
Mitchell-Thomé, R. C. undated.
(others cited in text where appropriate)

Table 9

Distribution of Soils on Fogo and Santiago

	Fogo		Santiago	
	Hectares	%	Hectares	%
Lithosols and Litholic soils	17,612	37	40,500	41
Andosols	9,996	21	-	0
Colluvial soils	7,616	16	-	0
Alluvial soils	-	0	2,970	3
Unconsolidated deposits	4,284	9	-	0
Isohumic soils (Chernozems)	1,904	4	15,850	16
Volcanic deposits	952	2	-	0
Vertisols	-	0	2,770	3
Para ferralites	-	0	1,980	2
Regosols	476	1	-	0
Other (built up areas, caldera)	4,760	10	34,650	35

Source: Freeman et al. 1978.

cultural use amount to 27 percent of the soils on Fogo and only 23 percent of the soils on Santiago. Fig. 3 shows the distribution of Isohumic soils on Santiago, where they are limited largely to the interior plateaus.

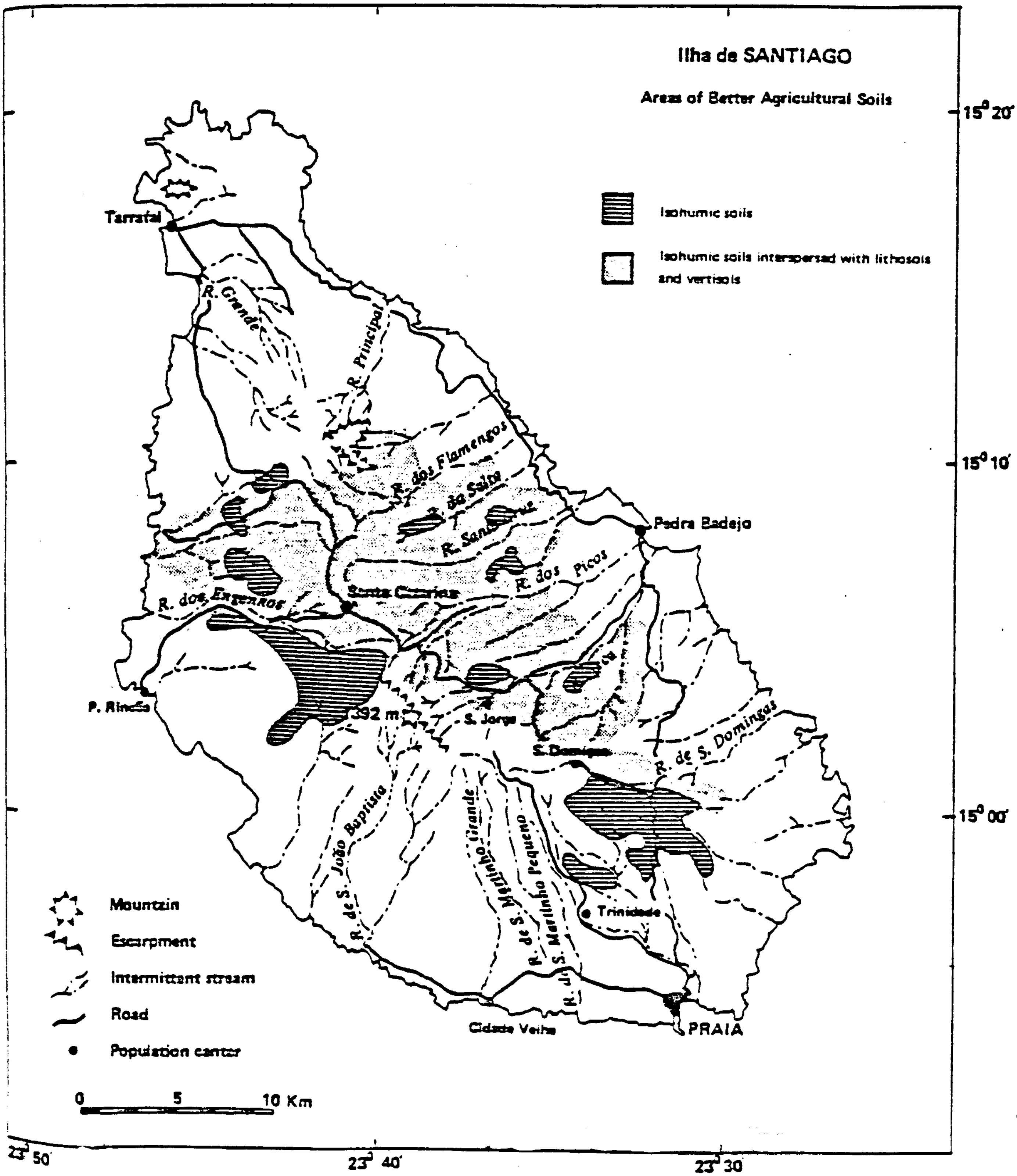
3.3 Water Resources [6]

3.3.1 Surface Water

The topography, geology, climate, and scarce vegetation of the Cape Verde Islands all encourage rapid surface runoff. Rains tend to come in torrential storms, the surface is low in water permeability and retention, and watersheds are steep. Peak flood flow rates range from two to five cubic meters per second per sq km for catchment areas of 10 to 50 sq km , with steep upper zones and areas of relatively impermeable geologic formations producing the highest rates. Flows persist near peak rates for no more than a few hours and 60 percent of flow occurs within two to ten days. Surface

[6] Source: Freeman et al. 1978.

Figure 3. Areas of Better Agricultural Soils on Santiago



Source: Freeman et al. 1978.

runoff, about 50 percent of rainfall, and totalling an annual average for the archipelago of 330 million cubic meters, is mostly wasted to the sea.

Control and utilization of runoff is difficult due to the nature of the flood wave, heavy loads of water-borne debris, and steepness of the terrain. Flash floods with nearly vertical wave fronts carry large loads of rocks, gravel, sand, and finer sediments. An estimated seven to eight meters of coarse deposits were laid down in successive floods over a 20 year period in the Ribiera da Torre on Santiago. The steep terrain makes dam sites scarce and reservoirs would be subject to rapid filling with erosional debris.

Present utilization of flood waters consists only of limited amounts of wild irrigation, entrapment of sediments by a few polders at high flow levels, and some slowing and diversion of runoff for artificial recharge of the groundwater. Further development of artificial recharge, construction of small reservoirs in headwater areas, and construction of underground dams through alluvial streambed materials to relatively impermeable rock could supply a total of 50 million cubic meters per year from surface water sources, enough to irrigate an additional 3000 hectares of land.

3.3.2 Groundwater

Groundwater is the only current source of irrigation water and the major source of domestic water in the islands. In most cases, it is obtained from natural springs, short horizontal drainage galleries, and shallow hand-dug wells in valley bottoms. Drilled wells were not constructed until 1970, and these are not deep. Although the same geographic and climatic factors which increase surface runoff also decrease groundwater accruals, the limited exploitation systems currently in use allow about two-thirds of the crudely estimated recoverable groundwater to waste to the sea (Table 10).

Three major volcanic formations differing in their hydrological capacities are found throughout the islands: an ancient (pre-Miocene) and partically impermeable basic formation, an intermediary (Mio-Pliocene) formation of major outflows which holds most of the islands' groundwater, and a recent formation of lavas and pyroclasts which locally forms a water-permeable covering. The influence of these formations on the hydrology of individual islands is affected by their extent, thickness and elevation of the bases, and location with respect to climatic zones. Further variation in local hydrological conditions is caused by the extreme heterogeneity of structure in the major formations, including intrusive dyking and tilting of the strata. These structural irregularities can result in intercrossing flows, veins, entrapped bodies of water, and other local variations in groundwater recharge, flow, and recovery potential which require more detailed geological information than now exists before groundwater recovery can be planned. Current rough estimates of total avialable groundwater in the archipelago range from 80 to 90 million cubic meters per year (Table 10).

Table 10

Estimated Groundwater Status and Development Potentials for Individual Islands

(10^6 cubic meters per year)

	Annual Accrual	50% Assumed Recoverable	Present Use	Development Potential
Santiago	58	29.0	13.9	15.1
Fogo	42	21.0	1.5	18.3
Brava	5	2.5	1.0	0.7
Maio	3	1.5	0.2	1.3
Boa Vista	3	1.5	0.5	1.0
Sal	1	0.5	0.1	0.4
Santo Antão	54	27.0	11.5	14.6
São Nicolau	9	4.5	0.8	3.3
São Vicente	1	0.5	0.5	0.0

Source: Freeman et al. 1978.

3.3.3 Cape Verde's Water Budget

Maximum potential water resources from surface water (50 million cubic meters per year) and groundwater (90 million cubic meters per year) total 140 million cubic meters per year. Projected domestic consumption for the year 2000, if supplemented by 3 million cubic meters per year from sea water desalination, would amount to 8 to 10 million cubic meters per year, leaving 130 million cubic meters per year for irrigation. This could conceivably irrigate a maximum of 8600 hectares (compared to the present 1850 hectares), presupposing improvements in desalination facilities for urban needs as well as increased efficiencies in the conveyance and application of irrigation water.

3.4 Vegetation [7]

3.4.1 General Features

No description of the original natural vegetation of the Cape Verde Islands exists, but 50 years after their discovery, some of the mountainous islands were reported to be well-forested, while the lower, flat islands had few trees but considerable grasses. Centuries of intense exploitation for fuel, construction, grazing and agriculture have vastly altered the character of the native vegetation by both the removal of natural forms and the introduction of exotics. Barbosa (in Bannerman and Bannerman, 1968) reported practically no relicts of native vegetation in good agricultural regions, and Freeman et al. (1978) did not observe a single intact stand of native trees.

When the first thorough botanical survey was conducted 50 years ago (Chevalier 1935), the flora consisted of about 600 species of vascular plants, of which half were cultivated plants or weeds introduced by man, and only 92 were endemic forms. The flora of the archipelago is therefore poor relative to other Atlantic islands such as the Canaries (480 endemic species) and Madeira (950 total species). The native flora is related to tropical African or Atlantic island forms, while the introduced flora is pantropical or cosmopolitan. Oddly, the cactus-like succulents (*Euphorbia* spp.) are rare in the archipelago, though they are common in the Canaries and arid North Africa.

Most of the vegetation is adapted to xeric conditions and erratic rainfall. Leaves are often tough, small, and drought-deciduous, thorns are common, and many species maintain themselves in drought-resistant resting stages such as seeds, bulbs, or rhizomes until the rains come. Rangeland bushes, succulents and grasses have been reduced to species with toxic sap, thorns, or other features unpalatable to livestock. Additional pressure during the recent drought has resulted in the trimming or removal of woody brush and leguminous trees for fuel and the failure of fruit and coffee trees. In 1978, Freeman et al. (1978) reported that virtually all plants in farmed areas and within a one-half days' walk from small villages had been removed.

3.4.2 Vegetative Zones

Cape Verde's vegetation falls within the general categories of African thorn savannah in transition to desert, and at higher elevations, xerophytic steppe. Due to the highly disturbed nature of the environment, almost no true vegetative associations exist today in the sense of a natural group of plants in equilibrium with the environment. Only in limited areas without agricultural value such as salty soils, sand dunes, or very rocky areas do remnants of the native floral associations persist.

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[7] Source: Amaral. 1964
Barbosa. 1968.
Chevalier. 1935.
Freeman et al. 1978.

Sand dunes, sandy beaches and sandy washes support the tree Tamarix gallica, the grass Sporobolus spictatus, and the spreading, dune-fixing Ipomaea pes-carpae. Saline soils have Arthrachemum glaucum in association with Suaeda volkensii and Zygophyllum fontanesii. Rocky areas at high altitudes have a variety of lichens, together with the fern Pteridium aquilinum.

The extensive, low-lying rocky plains or achadas found throughout the islands up to about 400 meters have an excessively impoverished and scanty flora. Native trees of the genus Acacia (A. albida, A. farnesiana, A. nilotica), formerly common in drainages or scattered throughout the achadas, have been largely replaced by the American mesquite (A. juliflora) and Parkinsonia aculeata. Grasses are predominately Aristida spp. (A. adcensionis, A. papposa and A. cardosai), and many of the herbaceous plants are weeds of cultivated areas but make fair browse. Among these are Lotus spp., especially L. glinoides, and Boerhavia viscosa, B. verticalla, and Acanthospermum hispidum. On Sao Vicente and Boa Vista, Sclerocephlus arabicus and Zygophyllum simplex with spiny fruits predominate. The calcareous soils of Sal, Maio, and Boa Vista are dominated by Asperagus scoparious with Polycarpea nivea and Sinapidendron glaucum.

The semi-arid zone extends from 400 to 1000 meters. In the more humid valleys on northeast facing slopes practically all native vegetation has been destroyed and replaced by cultivated species, especially sugar cane, coffee, bananas, and miscellaneous fruit trees, including papaya, mango and guava. Weedy invaders in this area are generally exotic composites. Lantana (Lantana camara), a hardy woody shrub valuable for holding soil, predominates elsewhere, along with sida (Bidens pilosa). Grasses in this area include Rynchelythrum spp., Panicum maximum, Setarium verticallata, Heteropogon contortus, and Hyparrhenia hirta; the latter, very adaptable and common throughout the archipelago, was very likely the most extensive ground cover on soils before the arrival of man.

At higher altitudes, the dominant plants include Furcraea foetida, a naturalized agave-like plant which spreads extensively by vivaparous runners, and the native shrubs Sideroxylon marmulana and Echium stenosiphon, all of which predominate on steep slopes and rocky outcrops. High altitude areas with lapilli have poor pastures with few grasses and a few shrubs of the composite family. The ground creeping Euphorbia tuckeyana, with toxic sap and no fuel value, is abundant in this region and probably formed a major open-steppe ground cover throughout the islands prior to human occupation. In high arid areas with good soils Heteropogon contortus and Andropogon gayanas are good ground cover grasses and make fair forage. The most common shrub growing on good high altitude soils is the spiny Dichostachys cineria used for stovewood.

3.4.3 Forest Plantations

Forest plantations amounting to 2040 hectares are distributed among six islands (Table 11), and are of two basic types: high elevation plantations on the windward, cloud covered peaks of the higher islands

(1330 hectares), and low elevation plantations of drought resistant legumes in the coastal plains where farming is not possible (710 hectares). High elevation plantations were started about 30 years ago, and low elevation plantations about 10 years ago.

High elevation plantations are situated from 800 to 1500 meters above sea level and consist principally of eucalyptus, Pinus canariensis, P. radiata, and Cupressus. The pines were planted only on Santo Antao, where natural regeneration has not taken place, apparently because seeds are sterile. Pinus radiata is estimated to produce between 10 and 15 cubic meters of fuelwood per hectare per year, while eucalyptus produces about four cubic meters per hectare per year.

Low elevation plantations have been established at elevations of 200 meters or less and consist primarily of mesquite (Prosopis juliflora) and Parkinsonia aculeata. On Boa Vista, where the oldest and most carefully managed plantations of mesquite exist, production is estimated at 1.0 cubic meter per hectare per year. Both Prosopis and Parkinsonia are viewed as having browse value, despite being thorny. Goats will eat Prosopis leaves and twigs only after they have been cut, thus conferring a unique advantage to this species. Also, Prosopis seems better able to reach groundwater than the native Acacia albida, which is considered too slow growing to use in plantations and is being slowly but surely exterminated.

Table 11. Area and Distribution of Forest Plantations[a]
(In Hectares)

	High Elevation (800 m to 1500 m)	Low Elevation (Below 200 m)
Santiago		
São Jorge[b]	250	
Curralinho	500	
Malagueta	150	
Trinidade		20
Santo Antão	500	50
Fogo	450[c]	350[d]
São Nicolau	30	40
Maio		200
Boa Vista		100[e]
Total	1330	710

[a]Estimates by Manuel Gonçalves, Emile Maudoux and Francisco Barbosa.

[b]Includes 100 hectares of *Khaya senegalensis* 100 hectares of eucalyptus, 5 hectares of *Grevillea robusta* and small areas of *Jacaranda mimosifolia* and *Ceiba pentandra*.

[c]Mainly *Cupressus*.

[d]Includes 300 hectares of *Parkinsonia* at the Mt. Genebra range rehabilitation experiment.

[e]Includes 80 hectares of *Dactylis canariensis*.

Source: Freeman et al. 1978.

3.5 Faunal Resources [8/]

3.5.1 Native Terrestrial Fauna

The native fauna of the Cape Verde Islands is depauperate, as is to be expected of small arid oceanic islands with a relatively recent history of volcanic activity. The native vertebrate fauna consists almost entirely of birds and lizards. There are no freshwater fish, since there is no permanent fresh water, and there are no amphibians or snakes. A single terrestrial tortoise (Pelusius derbianus) recorded from an islet in Praia Bay, Santiago, was probably brought by man. The only native mammal is the long-eared bat (Plecotus austriacus), a widespread palearctic species. The Senegal Green Monkey (Cerropithecus aethiops) has been introduced to Santiago, where it is a pest on fruit trees. Besides the domestic livestock animals previously discussed, man has also brought rats, mice and dogs. The 19 species of butterflies recorded from the islands are all common species of African origin.

Among the native reptiles are two marine turtles (Caretta caretta and Ertmochelys imbricata) which have been recorded breeding on the sandy beaches of the lower islands, but their eggs are taken for food and their current status is unknown. Thirteen species of lizards are native throughout the islands, of which 10 are endemic species. Among the latter are five species of the genus Mabuya and three species of the genus Hemidactylus. The remaining two endemic species are giant forms found only on the small desert islands Branco and Razo. One is a giant gecko (Tarentolla gigas) and the other a giant skink (Macroscincus coctei). The skink has been exploited for food and medicinal purposes by neighboring islanders, and is currently listed as an endangered species by the I.U.C.N.

There are 38 species of regularly breeding birds on the islands, of which about a third are seabirds. Most of the landbird populations are sparse. Two of the native land birds are endemic: the Razo Lark (Aluada razae), restricted to the islet of Razo, and the Cape Verde Warbler (Acrocephalus brevipennis), found on Santiago, Brava, and Sao Nicolau. The Razo Lark is listed as endangered by the I.U.C.N. due to its restricted distribution, though current information on its population size is unavailable.

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[8] Source: Aubray. 1976.
Bannerman and Bannerman. 1968.
Bertin. 1946.
Dorst . and Navrois. 1966.
Freeman et al. 1978.
International Union for the Conservation of Nature and Natural Resources (IUCN). 1975.
IUCN. 1976.
Riley. 1968.

3.5.2 Marine Resources and Fisheries

Although the oceanic location of the Cape Verde Islands and the proximity of coastline throughout the islands suggests that marine resources should play an important economic and nutritional role in Cape Verde, this is not the case. The fisheries sector contributes only about 3.5 percent of the national economy, and annual per capita fish consumption is about 12 kilograms, or one fifth that found in more developed fishing nations.

Several factors are responsible for limiting the use of marine resources in the islands: lack of modern fishing vessels and techniques, geographic and seasonal weather conditions, and a narrow continental shelf around the islands.

There are about 3000 fishermen on the islands, about half of which are on Santiago and 30 percent on Sao Vicente. Most of them are artesanal fisherman who fish from small (4-7 meter) sailing boats with rod and line during about 8 months fo the year, and especially from July to October. High seas and winds from December to March discourage fishing activities. Rocky shores with few natural harbors also limit fishing from the windward northeastern shores where rural population density is concentrated because of better rainfall. Fish for local consumption is sold fresh or salted and/or sundried.

In addition to subsistance fishing, fishermen also sell their catch to canning factories located on Santiago, Boa Vista, Sal, Sao Nicolau, and Maio. The factory owners also own and operate motorized vessels of 12 to 15 meters, which take crews out as far as 50 km. Artesanal fisheries account for about 2/3 of the total annual catch of 6000 metric tons, with the remaining third from the commercial fleet.

Tuna of three species constitute about 85 percent of the catch, other pelagic and demersal species about 14 percent, and lobster about one percent. Of the tuna, about 55 percent are yellowfin (Neothunnus albacores), 30 percent are skipjack (Katsuwanus pelamys), and 15 percent are big eye (Parathunnus obesus). Other pelagic and demersal species include mackerel, carangids (Decapturus) and sparids (Pagellus mormyrus). The lobster catch, which is taken in large traps and frozen for export by air to Portugal, consists mainly of three species: green lobster (Palinurus regius), red lobster (P. guttatus) and rock lobster (Scyllarides latus).

The potential for expansion of the fishing industry depends not only on improving the fishing fleet and handling facilities, but on the available resources, which may be limited by the narrow continental shelf (3500 sq. km. at a depth of 200 meters or less) and the density of fish. Data needed to estimate the potential catch are lacking, and estimates range from 8000 to 30,000 tons per year. The most likely source of improvement is the lobster catch, currently at about 60-80 tons per year, but potentially about 500 tons/year. Other possible uses of marine resources in the islands include the use of seaweed (Ulva) for organic matter and minerals, and fish guts and heads for fish meal or fertilizer.

4.0 Environmental Problems and Prospects [9]

In Cape Verde, as is true everywhere in the world, environmental problems are human problems which arise either when the natural environment is not suited to human purpose or when human use has degraded the environment. The history of recurrent famine and the present barren state of the land in Cape Verde illustrate man's ineffectual adaptation to Cape Verde's natural conditions. The challenge today is to find ways to restore the environment and to benefit from it without diminishing its value. This section outlines the principal environmental problems facing Cape Verde, their causes, and steps which might be taken to resolve them. Although treated separately, the problems are of course inevitably linked by a chain of shared causes and effects. International aid programs related to environmental problems are summarized in Appendix II.

4.1 Soil Conservation

The natural environment of Cape Verde is conducive to soil erosion. Steep watersheds and brief but torrential rains cause rapid runoff, and consistent high winds also add to soil erosion and sand drift where the ground is unprotected. Nonetheless, the natural vegetation of Cape Verde was considerably developed prior to man's arrival and played a vital role in stabilizing soils and adding organic material to them. Since then, removal of vegetation for fuel and construction, clearing for agriculture, and intensive livestock grazing, particularly by goats, have resulted in almost totally bare soils vulnerable to erosion in both cultivated and grazed watersheds. The common practice of pulling up vegetation by the roots for fuel or livestock feed disturbs the soil, reduces organic content, and adds to erosion problems. On steep slopes planted in corn, 12-15 mm. of soil can be lost in a single rainstorm.

4.1.1 Physical Modifications

Since 1976, rural conservation works have been under construction, including various kinds of physical structures designed to modify slopes and stream gradients such as earth or stone-walled terraces, contour ditches to temporarily slow sheet runoff, and small to large check-dams in stream bottoms. Check dams built in previous years have filled up with sediment, and there are plans to raise dams once they have filled. There is little experimentation with different kinds of terracing on slopes for runoff and erosion control, or with the proper dimensions of contour ditches. The estimated cost of terracing 100 percent slopes is US $17,600 per hectare.

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[9] Source: Freeman et al. 1978.
Horenstein. 1979.
U.S. AID. 1979.

In Santo Antao, the Dutch government is sponsoring research in three 400 hectare sub-watersheds with three kinds of management: with vegetative cover only, with physical structures only, and with conservative farming and land use practices. Instrumentation for monitoring climate and runoff in the three watersheds are now installed but results have yet to be reported.

4.1.2 Vegetative Protection

The establishment of ground cover for erosion control has been generally neglected. Only on Mt. Verde in Fogo has controlled establishment been attempted, with considerable success. A 300 hectare plot in a traditionally grazed arid zone was fenced, weedy species were removed by hand, and Parkinsonia was planted in five-hectare squares. After six years, the regrowth of grasses was impressive. The hand-weeding was an important component of this trial, since undesireable species tend to be more vigorous and have relatively more numerous seeds. About 6 to 10 years appears to be necessary for regeneration of groundcover on protected areas. Planting of windbreaks to reduce wind erosion also needs to be implemented.

Regeneration of range requires protection from livestock, which is difficult considering that any and all land of even the poorest quality range has traditionally been grazed and most families own animals. Livestock populations could be kept low until range has regenerated, or new systems of raising livestock with cut forage, silage or browse instead of grazing could be developed. International assistance would probably be required.

4.1.3 Restoration of Organic Material

The loss of organic matter from soils due to erosion and the practice of completely removing vegetation for livestock feed and fuel has reduced soil fertility and water-holding capacity. The restoration of organic matter would require amounts of several tons per hectare and continuous additions to maintain proper levels. The planting of "green manure" crops and fallowing is necessary. Seaweed could be harvested as a source of organic matter, as has been done elsewhere.

4.2 Water Supplies

Physical conditions in the Cape Verde Islands make access to water for agricultural and domestic purposes difficult. Rainfall is erratic in occurrence, amount and distribution. Constant winds cause water loss by evaporation and evapotranspiration from soils and vegetation. Steep slopes and degraded soils lacking in organic matter and vegetative cover promote rapid runoff. Streams run only intermittently, mainly after heavy rains, when peak flows can be destructive and difficult to manage. The steep-sided, steep-sloped narrow valleys typical of the windward sides of the mountainous islands, where most rain falls, are not suited to reservoirs. Groundwater resources are poorly known and difficult to estimate because of the complex nature of the volcanic formations in the islands. There is a potential for seawater intrusion if water is pumped from low-lying aquifers, such as valley bottom sediments near coasts.

4.2.1 Increasing Water Supplies

There is an overwhelming human need for more water in the Cape Verde Islands, particularly pumped groundwater to increase irrigated land and thereby decrease dependence on the erratic rainfall. Preliminary estimates indicate that water supplies could be increased to 140 million cubic meters per year compared to the present use of 30 million cubic meters per year. This could be accomplished by increasing surface water storage where possible, inducing artificial recharge of groundwater by slowing and dispersing surface runoff, and drilling wells to tap groundwater resources. By increasing the water supply, an additional 6,300 hectares could be added to the 2300 hectares presently developed for irrigation. There is a potential for increasing water supplies for both domestic use and irrigation by desalinization, preferably with solar energy. Mesh condensation devices can enhance water derived from the atmosphere to 78-229 percent greater than rainfall for local supplies in areas of proper elevation (Cunha, 1964).

4.2.2 Improving Water Conservation

In light of the scarcity of water on Cape Verde and the expense of developing increased water supplies, steps must also be taken to increase the efficiency of water use, particularly for irrigation. At present, irrrigation efficiency is low and much water is wasted, especially on banana plantations, due to poor control of flows, uneven water distribution, and excessively heavy, infrequent application of water on rapidly draining, coarse soils. Some aqueducts now in use are losing considerable amounts of water because they are broken or unlined. To prevent this wastage of irrigation water, the current irrigation system should be modernized and kept in good repair. Carefuel consideration should also be given to the selection of crops for irrigation so as to minimize loss by evapotranspiration, and the reuse of waste water in urban areas for irrigation.

4.2.3 Improving Background Information

Efficient planning for exploitation of the water resource is currently hampered by a lack of basic survey information. A systematic and sustained effort to survey and monitor all uses and resources within watersheds and geologically defined aquifers is necessary. Calculations of available water reserves must be done on an island-by-island basis to be meaningful, including the measurement and location of irrigable soils and their relationship to water resources. Specific steps which can be taken include:

1) Improve Groundwater Data. Monitor production of all major wells and use the data for water balance studies and aquifer management. Include water quality information in monitoring programs. Explore and test-pump representative geologic formations for aquifer development.

2) Improve Surface Water Data. Install streamflow measuring stations on representative northeast- and southwest-facing watersheds of 50 sq. km. or less, representing both higher and lower elevation catchments.

3) Improve Climatological Data. Establish a network of rain gauges on at least a 10 km square grid, and install recording rain gauges on northeast- and southwest-facing slopes to measure rainfall of short duration.

4.3 Land Use Efficiency

Given that 70 percent of Cape Verde's population lives in rural areas, and only 15 percent of the land is suited to agriculture, rural population density is exceptionally high. Average density on agricultural land is 500 persons per sq. km., with a range of 200 persons on Fogo to 1000 persons on Brava. Adding to this intense population pressure on the land is the physical pattern of highest rainfall on mountain slopes, which tends to concentrate agriculture and population in steep areas most vulnerable to soil erosion. Under these circumstances, efficient land use to obtain the maximum agricultural yield with the least damage to the environment is a necessity.

4.3.1 Improving Yield

Improving agricultural yield in Cape Verde is critical for two reasons. First, food supplies are not sufficient to feed the present population, and without international aid, famine would occur. Second, improving yield can release land currently used for environmentally damaging forms of agriculture so that alternate uses better suited to local conditons can be instituted. Agricultural production in Cape Verde has become stagnant because all land cultivable by traditional means is being used and because modern agricultural practices are not in use. Among the methods which might be used to increase agricultural yield are:

1) Use of Improved Varieties. Many cultivars in use in Cape Verde are old varieties which could be improved by the introduction of higher yielding and more drought-resistent types. For example, sugar cane production on irrigated land could be doubled by use of improved varieties, freeing 50 percent of the area now planted in cane for planting in food crops.

2) Diversification of Crop Plants. Production could increase by the use of crops better suited to certain ecological conditions than corn and beans, as for example sorghum, millet or cassava in more arid zones. Crop diversification would also reduce the probability and potential for loss from epiphytotic disease.

3) Increase the Area under Irrigation. Estimates presented in the last section indicate that irrigated, intensively producing croplands could be increased about threefold.

4) Use of Fertilizers and Pesticides. Neither are widely employed at present.

5) Improve Storage Facilities for Grains. There is considerable loss at present to rodents, insects, and fungi which could be eliminated by improved storage facilities.

Such improvements in agricultural practices in Cape Verde could increase the yield from irrigated lands to supply the demand for fresh fruits and vegetables both now and in the future. However, it is unlikely that self-sufficiency in corn production can ever be realized even with modern agricultural practices, because land and water resources are simply too scarce. However, improved yields could at least close the gap between supply and demand, somewhat in the case of corn and completely for fruits, vegetables and animal proteins.

4.3.2 Improving Energy Sources

A major pressure on both the land and vegetation of the Cape Verde Islands is created by the demand for fuelwood. The use of imported kerosene and butane in place of native fuelwood is too costly for the rural population, so that the development of alternative energy sources and the creation of managed fuelwood plantations is of highest importance.

Cape Verde could potentially provide for a good portion of its needs in domestic fuelwood at present rates of consumption. An estimated potential production of 45,635 cubic meters of wood per year (Table 12) would supply about 95,000 people. Much more area could possibly be used for lower elevation plantations, but these produce at only one-tenth the rate of the cool, moist sites at higher elevations. Higher sites are relatively limited, and better used for timber production, so expansion would have to be at lower elevations.

Development of alternate energy sources is still in the embryonic stages, but the government of Cape Verde has recognized the following areas for future implementation:

1) wind power for water pumping, cooling, and electric power;

2) solar energy for electricity, desalinization, heating water, cooking, and drying fish;

3) biogas for lighting, cooking and fertilizer; and

4) geothermal energy for electricity and heating.

In addition, methods for reducing fuel consumption such as the substitution of pressure cooking for the long process of boiling corn over an open fire should be considered.

Table 12

Potential Fuel Wood Production

	Presently Forested	To Be Planted	Additional Potential	Potential Yearly Production (m^3)
High elevation planations	1,330	1,350	1,320[a]	40,000
Low elevation plantations	710	1,425	3,500[a]	5,635
Total				45,635

[a]From estimates by M. Goncalves.

Source: Freeman et al. 1978.

4.3.3 Changing Land Use Patterns

Many of the environmental problems in Cape Verde stem from inappropriate land use practices, particularly the intensive cultivation or grazing of steep and arid areas which are not suited to these purposes. As improved agricultural methods are introduced, these lands should be freed and managed for less intensive uses. In the steeper zones in excess of 40 percent slope, only perennial economic crops or plants such as grasses, shrubs, bushes and trees should be used, so as to provide browse and/or firewood. Minimum tillage and judicious grazing and cutting are possible in these areas. Over the long term, watershed conservation may entail a shift to different crops than corn and beans and the displacement of people from critical areas. Such measures will require land capability surveys and socio-economic studies to develop alternatives for farmers that may have to be resettled by such a major shift in land use practices.

4.4 National Development and the Resolution of Environmental Problems

The government of Cape Verde is in the process of preparing its first National Economic Development Plan, to be completed in mid-1980. In the interim, an emergency plan for short-term public works projects has been in effect since 1979. The long-term goals of the National Economic Development Plan are currently recognized as follows:

1) increased food production;

2) water resource development;

3) environmental rehabilitation and conservation;

4) development of energy resources;

5) employment opportunities for the rural poor; and

6) increasing accessibility of basic services to rural communities.

These goals, particularly the first four, are not only immediate necessities for the economic development of Cape Verde but are essential to the improvement of its environmental conditions as well.

In order to stop the historical process of environmental degradation in Cape Verde, there must be major changes in land use stimulated by modern agricultural techniques and causing less intensive exploitation of the land. However, even with modern high-technology crop husbandry, neither present nor future demands for corn can be met. Therefore, there must be new economic oppotunities in urban areas to provide a market for modern agricultural products, to generate exportable products that could be traded for food, and to absorb the surplus rural population in productive jobs. Ultimately, then, the successful development of Cape Verde will depend not only on conservation practices and improved agricultural yield, but on the development of urban jobs, preferably in light industry.

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APPENDIX I

Structure of the Government

Appendix I. Structure of the Government [10]

The government of the Republic of Cape Verde began a few days prior to officially achieving independence from Portugal (on July 5, 1975), with the election of the 56-member National People's Assembly. The Assembly was chosen by universal suffrage of persons 18 years of age and over from a list of candidates submitted by the single official party, the African Party for the Independence of Guinea and Cape Verde (PAIGC). Upon independence, the single house legislature elected the executive branch of the government. The drafting of a formal constitution has been deferred until the issue of unification with Guinea-Bissau is settled. Until the constitution is drawn up, the Law Establishing the Political Organization of the State, promulgated in July, 1975, and affirming the supremacy of the PAIGC over the state structures, remains in effect.

The Government of Cape Verde is organized into three principal branches: legislative, executive, and judicial. The legislative branch of the government is the popularly elected National People's Assembly. Its principal functions are to 1) take the necessary actions to achieve various political, economic, social, cultural, defense, and secutity programs defined by PAIGC; 2) elect the President of the Republic who is responsible to the Popular National Assembly; 3) elect the Prime Minister as proposed by the President of the Republic; 4) elect the President of the Popular National Assembly; and 5) vote laws and resolutions. The Popular National Assembly can delegate legislative authority for specified areas to the Council of Ministers, as has been done in the areas of water, and territorial sea and economic zones.

The executive branch of the government is headed by a Prime Minister who is responsible for implementing the laws and resolutions voted by the Assembly. There are ten principal Ministries: 1) Cabinet of the Prime Minister; 2) Ministry of Foreign Affairs; 3) Ministry of Defense and National Security; 4) Ministry of Economic Coordination; 5) Ministry of Education and Culture; 6) Ministry of Transportation and Communications; 7) Ministry of Rural Development; 8) Ministry of Health and Social Affairs; 9) Ministry of Public Works and 10) Ministry of Justice.

The Prime Minister is responsible for internal administration of the country through the Secretary of State for Internal Administration Public Functions, and Labor. The country is divided into *Concelhos* (districts), which are further subdivided into *Freguesias* (parishes) for purposes of administering public programs (Table 13). Each *Concelho* is directed by a Delegate of the Ministry of Internal Administration, assisted by a Deliberative Council whose numbers vary according to local needs. Both Delegates and Councils are named by the Prime Minister. In each *Freguesia* an administrative agent maintains contact between communities of the *Freguesia* and the delegate. The Prime Minister also is responsible for cooperation and planning through the Secretary of State for Cooperation and Planning.

Other ministries mainly carry out programs in functional areas such as transportation, health, education, and rural development, as suggested by their names. Such programs are usually implemented on a regional or local basis through regional offices, in coordination with the Delegate of the Prime

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[10] Source: Freeman et al. 1978.
U.S. Office of Foreign Disaster Assistance. 1979.

Minister. Government regulation and control of the economy and fiscal policy are maintained through the Secretariats of State for Commerce, and of the Ministry of Economic Coordination for finances. Monetary policy is tightly controlled through the Bank of Cape Verde, which is operated as a central and commercial bank.

It should be noted that the Prime Minister rather than the President of Cape Verde is the head of the executive branch. The President of the Republic is titular head of the government and directly responsible to the Popular Assembly. The current President also serves as Secretary General of PAIGC.

Prior to independence, the Cape Verde Islands were subject to the Portuguese civil and criminal code. Most of the legal code currently in effect was inherited from the Portuguese. The present judicial system is headed by a National Council of Justice composed of three judges appointed by the government and six assessors designated by the legislature who hear appeals from elected courts of first instance. A judiciary protocol signed by Cape Verde and Guinea-Bissau in April, 1976, unites the two countries as a territory for the purposes of laws, legal personnel, prisons and punishment for crimes.

Government programs related to environmental problems, including soil and water conservation and forestry management, are administered by the Ministry of Rural Development (MDR). Figure 4 shows the administrative structure of the MDR.

Table 13

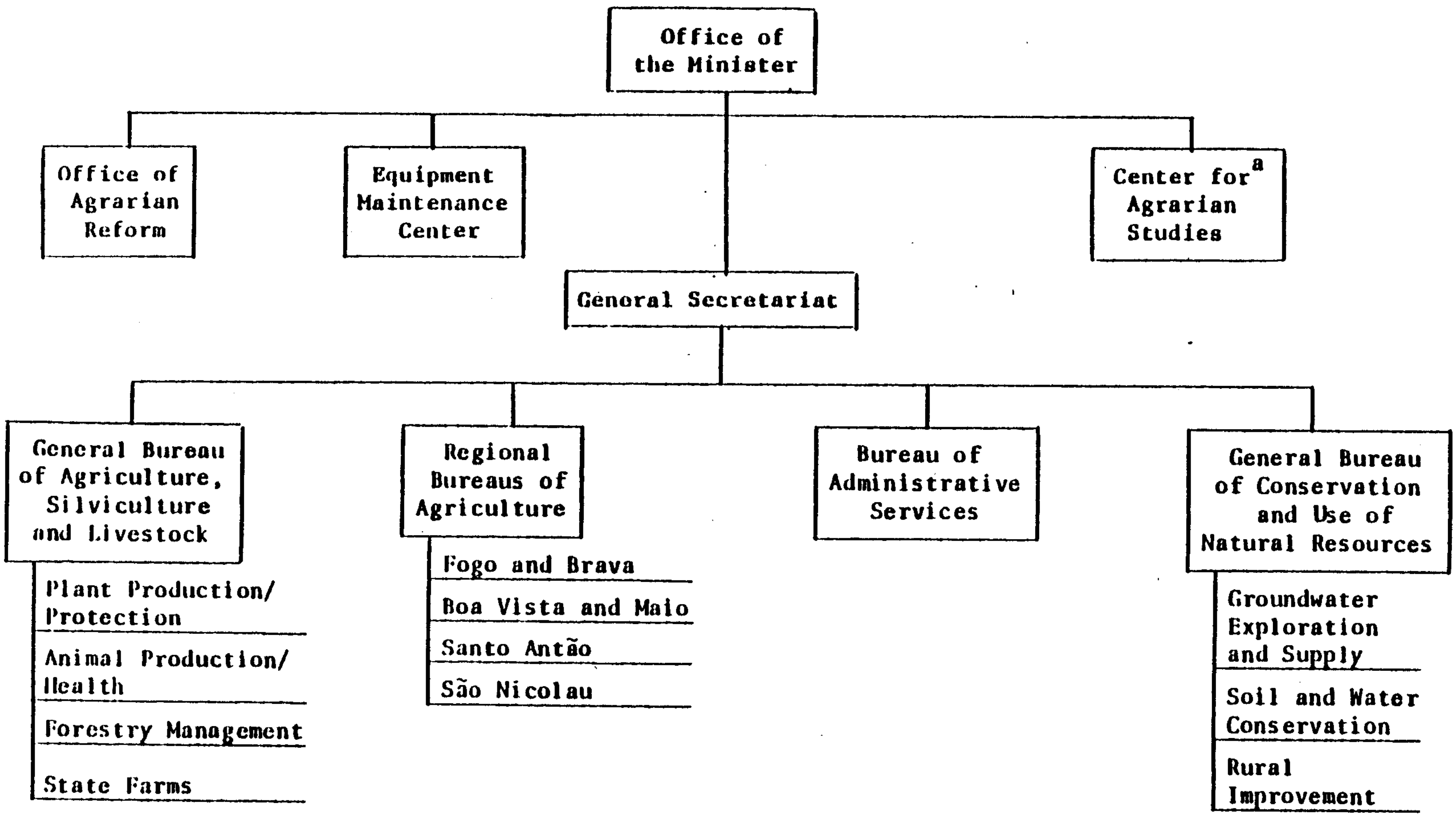
Administrative Division of Cape Verde

Islands	Conselhos	Freguesias
Boa Vista	Boa Vista	Santa Isabel
		São João Baptista
Brava	Brava	São João Baptista
		Nossa Senhora do Monte
Fogo	Fogo	Nossa Senhora da Conceição
		Nossa Senhora da Ajuda
		São Lourneço
		Santa Catarina
Maio	Maio	Nossa Senhora da Luz
Sal	Sal	Nossa Senhora das Dores
Santiago	Praia	Nossa Senhora da Graca
		Nossa Senhora da Luz
		Santíssimo Nome de Jesus
		São Nicolau Tolentino
		São João Baptista
	Santa Catarina	Santa Catarina
		São Salvador do Mundo
	Santa Cruz	São Lourenço dos Orgãos
		São Tiago Maior
	Tarrafal	Santo Amaro Abade
		São Miguel Arcanjo
Santo Antão	Paul	Santo Antonio das Pombas
	Porto Novo	Santo André
		São João Baptista
	Ribeira Grande	Nossa Senhora do Livramento
		Nossa Senhora do Rosario
		Santo Crucifixo
		São Pedro Apóstolo
São Nicolau	São Nicolau	Nossa Senhora do Rosario
		Nossa Senhora da Lapa
São Vicente	São Vicente	Nossa Senhora da Luz

Source: Freeman et al. 1978.

Figure 4

Organization of the Ministry of Rural Development (MDR), Cape Verde, 1978



[a] The Center of Agricultural Studies is programmed to begin functioning in late 1978.

Source: Freeman et al. 1978.

APPENDIX II

National and International Programs Related to Environmental Problems

Appendix II. National and International Programs Related to Environmental Problems[11]

1. National Programs

As outlined in Appendix I, national programs in the area of conservation are administered by the Ministry of Rural Development (MDR). The MDR's budget is divided between operations, which is used to finance basic programs and services, and emergency programs, which are designed to reduce rural unemployment and relieve drought-related suffering. About 90 percent of the total budget is currently directed to emergency programs, especially public works projects aimed at relieving rural unemployment associated with the drought. Public works projects are concentrated on improving watersheds through construction of check dams, dikes, and terracing to improve groundwater recharge and reduce soil erosion and flooding. Two-thirds of the operations budget is allocated to personnel, many of whom are low-skilled, temporary employees involved in direct or indirect support for the emergency public works programs. This emphasis on emergency measures means that long-term planning and projects in agriculture and conservation are neglected at present. A shortage of trained professional staff is also a serious problem.

2. Bilateral International Programs

a. U.S. AID. Provides support directly to Cape Verde as well as through regional programs, such as the Sahel Food Crop Protection project and CILSS. Bilateral assistance has been directed primarily to the island of Santiago, particularly for the construction of erosion control and water-spreading structures in the valleys of Rio Seca, Rio dos Picos, Sao Domingos, and Rio dos Engenhos, and for the development of groundwater for irrigation in the vicinity of Tarrafal. Goals and strategies of the watershed program are outlined below:

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****************************************************************************************
*  COUNTRY/BUREAU: CAPE VERDE                    PROJECT: 6550006   SUB-PROJECT: 00   *
*                                                                                      *
*  TITLE: WATERSHED MANAGEMENT                   INITIAL FY:        FINAL FY:          *
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APPROXIMATELY 80 % OF THE ACTIVE POPULATION IN CAPE VERDE IS EMPLOYED IN AGRICULTURE, PRIMARILY AS SMALL-SCALE SUBSISTENCE FARMERS. BECAUSE OF LACK OF RAIN, OVERGRAZING, AND POOR FARMING METHODS, THE COUNTRY'S VEGETATION BASE HAS BEEN DESTROYED. HOWEVER, ON THE LARGER ISLANDS,POTENTIAL EXISTS FOR THE DEVELOPMENT OF AGRICULTURE DUE TO THE PERMEABLE STRUCTURE OF THE SOILS AND AVAILABILITY OF NDERGROUND WATER.

STRATEGY: 3-YEAR PROJECT CONSISTS OF GRANT AND TECHNICAL ASSISTNACE TO ESTABLISH A VIABLE WATERSHED MANAGEMEN PROGRAM IN CAPE VERDE. USAID ALSO PROVIDES PARTICIPANT TRAINING, CONSTRUCTION EQUIPMENT, AND COMMODITIES. HOST COUNTRY PROVIDES FARM LAND, STAFF SALARIES, EQUIPMONT, AND ENGINEERING AND AGRICULTURA SERVICES.

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[11] Source: Freeman et al. 1978.

GRANT AND TECHNICAL ASSISTANCE ARE PROVIDED TO THE GOVT OF CAPE VERDE TO ESTABLISH A VIABLE PROGRAM IN WATERSHED MANAGEMENT. A SYSTEMATIC APPROACH EMPLOYING AERIAL PHOTOGRAPHS WILL BE WILL BE UTILIZED TO DEVELOP WATERSHED MANAGEMENT PLANS FOR EACH WATERSHED.
1974 DRY MASONRY CHECK DAMS WILL BE CONSTRUCTED FROM STONE WITHOUT CEMENT MORTAR TO CATCH ERODED SOIL & SLOW THE STREAMS, TORRENTIAL FLOW. WIGHT SUBTERRANEAN IMPERMEABLE DAMS WILL ALSO BE CONSTRUCTED ON SITES WHERE UNDERGROUND WATER CAN BE FOUND. CHECK DAMS WILL BE BUILT AS RISERS TO THE SUBTERRANEAN DAMS TO SLOW DOWN FLOODS, USING DEPOSITS OF ROCK AND SAND BEHIND EACH DAM TO INCREASE WATER CATCHMENT CAPACITY. IN ADDITION, ROCL TERRACES WILL BE CONSTRUCTED FROM THE ABUNDANT SUPPLY OF STONES USUALLY LOCATED IN THE IMMEDIATE CONSTRUCTION AREA, AND EARTH CONTOUR DITCHES WILL BE CONSTRUCTED BETWEEN THE ROCK TERRACES. ONE SMALL RESERVOIR WILL BE CONSTRUCTED IN THE SANTA CRUZ VALLEY WHERE A NATURAL BASIN WITH NARROWING ROCK FORMATION REQUIRES A DAM OF MINIMUM PROPORTIONS.
AGRICULTURAL EXTENSION ACTIVITIES WILL BE IMPLEMENTED CONSISTING OF DETAILED STUDIES OF SOCIAL CONDITIONS, LAND USE AND LAND CAPABILITY IN TWO PILOT SUB-WATERSHEDS; A PRECISE DETERMINATION OF THE NECESSARY CHANGES IN LAND USE AND SUBSEQUENT SOCIAL CHANGES; AND A PROPOSAL FOR INSTITUTIONAL MEASURES TO COMPENSATE FARMERS WHO MUST CHANGE THEIR CROPS OR SEEK MORE SUITABLE LAND. FARMERS WILL BE TAUGHT AND ENCOURAGED TO ALTERNATE STRIPS OF PERENNIAL COVER (ANGOLA BEANS) WITH STRIPS OF CORN, OR PLANT OTHER CROPS SUCH AS MILLET OR SORGHUM BECAUSE FO THEIR RESISTANCE TO DROUGH, SHORTER GROWING SEASON, OR SOIL HOLDING QUALITIES.
BENEFICIARIES WILL BE THE POOR RURAL FARMERS LIVING ON THE ISLAND OF SANITIAGO.

1.POOR RURAL MAJORITY OF CAPE VERDE PROVIDED INCREASED EMPLOYMENT IN AGRICULTURE. 2.UNDERGROUND SOURCES OF WATER AVAILABLE FOR AGRICULTURE AND DOMESTIC USE INCREASED.

PURPOSE: 1.GOVT OF CAPE VERDE HELPED TO ESTABLISH A VIABLE PROGRAM IN WATERSHED MANAGEMENT INCLUDING A PILOT AGRICULTURAL EXTENSION SERVICE FOR SMALL-SCALE FARMERS. 2.SURFACE OF PRODUCTIVE LAND AVAILABLE TO AGRICULTURE INCREASED.

1.WATER AND SOIL CONSERVATION STRUCTURES CONSTRUCTED. 2.PILOT AGRICULTURAL EXTENSION SERVICE ESTABLISHED

b. France. Except for funding the nematology laboratory in the Sao Jorge agricultural experiment station on Santiago, French assistance is concentrated mainly on the island of Sao Nicolau. Projects on that island include groundwater exploration, development of a master plan, and improvement of the fisheries industry.

c. Federal Republic of Germany. Germany has concentrated assistance on Fogo and on helping build the biological pest control capability of the Sao Jorge experiment station on Santiago. The principal project on Fogo is the Mt. Genebra Irrigation Cooperative, which pumps water to irrigate a 15 hectare farm and for domestic uses. Other projects for Fogo include a development plan and a hydrological study. An agricultural and social development project including the development of groundwater resources is also being funded on the island of Maio.

d. Belgium. A five-year reforestation project for Santiago and Maio was designed in 1977 and funded in 1978. It includes reforestation of 1350 hectares at high elevations on Santiago and 1425 hectares at low elevations on Santiago and Maio, surveys and management plans for existing plantations, research and trials with drought-resistant and dune-stabilizing species, and training of Cape Verdians.

e. Netherlands. The Netherlands assistance is concentrated on the island of Santo Antao. In addition to the experimental watershed management project outlined in section 4.1.1, there is also an irrigation project for the valleys of Janela and Antonia on the northeast coast, and a development plan for the entire island. Outside of Santo Antao, Dutch assistance includes the construction of a soil and water laboratory at the Sao Jorge experimental station on Santiago, the channelization of the Trinidade river on Santiago, and improvement of fisheries and fish processing and storage facilities in Mindelo, Sao Vicente.

f. People's Republic of China. Technical assistance is being provided to develop irrigated agriculture on the elevated and densely populated plateau of Achada Falcoa on Santiago.

g. Switzerland. Swiss aid is concentrated on the island of Boa Vista for the development of vegetable horticulture and soil conservation.

h. Others. Portugal, Brazil, and the USSR all provide help in technical training and education. The USSR also has sixteen doctors stationed in the islands. Brazil plans to provide equipment for water exploration.

3. Multilateral International Programs

a. United Nations. The U.N. Development Program provides assistance in agriculture, forestry and groundwater exploration, fisheries, and transportation and communication. Other U.N. assistance includes the provision of health training, laboratory experts, purchase of health supplies and equipment by WHO. UNICEF provided funding for windmills for pumping water.

b. CILSS and the Club du Sahel. Assistance being provided to agriculture includes design and eventual financing of projects in reforestation, soil and water conservation, plant protection, hydrology and climatology, animal husbandry, agricultural production, and agrometeorology. Health assistance involves renovation of basic health units, rural water supply, food assistance and health education.

c. African Development Bank. The ADB's assistance includes telecommunications, rural development, and an economic study on water and dry dock development at Mindelo. Total assistance in 1978 was $8.2 million.

d. European Economic Community. The EEC supplied animal rations in 1977 for the Livestock Salvage Program. Other assistance includes environmental sanitation, water supply, hydro-agricultural works and power.

APPENDIX III

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1. General References on Cape Verde
2. Geology
3. Agriculture, Soils, and Water
4. Flora and Fauna (including Forestry and Fisheries)
5. Health

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