Working Paper

PDE-CAPE VERDE: A Systems Study of Population, Development, and Environment

Anna Wils

WP-96-9
January 1996

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Contents

Abstract

This study is an holistic analysis of population, socio-economic development and the environment (PDE) in a case study of an arid island state, Cape Verde. It describes and analyzes the dynamics of: how population change leads to economic reaction; how economic activities are shaped and/or constrained by the natural environment; how the environment influences the population and its society.

The study rests on two tiers of research. The first is an historical analysis of the case country with qualitative and statistical detail, contained in five chapters: history; population; social factors; economy; and environment. It includes a demographic method to analyze effects of mortality increase; and to estimate migration and fertility. The second tier is simulation modeling, contained in three chapters: on other models; the PDE model; and the scenarios. The PDE simulation model combines multi-state population projection; a semi-equilibrium input-output model; and a water and agriculture model. The model is used to make an historical scenario and future scenarios of the case country. This dual approach combines the detail and the nuances which are visible to the human mind's interpretation of a field of facts with the mathematical consistency that the computer contributes.

A study of Cape Verde provides insights the role of emigration, remittances and foreign aid in development. It also analyzes the effects of having a pool of fixed renewable natural resources (rain-water) and of competition in an economy that is largely determined by external forces. It shows some dynamics of limitation that can be over-looked in the study of larger countries, but which are present in some form in every region.

Acknowledgments

First: thanks to the people of Cape Verde, who make their country such an interesting and inspiring place to be and to study, and who provided me with a warm welcome, ready information, and much help during my stay with them, in particular to the Ambassador of Cape Verde in Bonn Antonio Pires, José Luis Rocha, Manuel Pinheiro, Péricles Barros, Júlio Morais, José de Sena Monteiro, Ms. Fortes, and the Director of the Family Planning Program of Cape Verde. Also to José Brito at the UNDP in Abidjan.

Thanks to the people at the Austrian Ministry for foreign Affairs for their help, particularly in the beginning of the project.

Many thanks to Wolfgang Lutz for his consistent support and for providing me the liberty at IIASA to work on this study, and to Gustav Feichtinger, Einar Holm, Warren Sanderson, and Peter de Jánosi at IIASA for invaluable comments. Thanks to Anka James at IIASA for making the figures. Thanks also to Maartje and Wilbert Wils for reading and commenting drafts.

Their input and that of countless others have helped me to write this paper. All mistakes, misunderstandings that remain, however, are mine only.

This project was partly financed by the United Nations Fund for Population Activities.

Chapter 1

Introduction

1.1 PDE-introduction

In the past three years, there have been three global United Nations summits: in Rio de Janeiro, Cairo and Copenhagen. It is no coincidence that these conferences followed closely upon each other. Each of them highlighted on broad sector – environment, population, and socioeconomic development – of a subject that is inherently all-encompassing, namely, the future of human kind in a globally linked world.

It is not clear yet how to analyze simultaneous and connected problems in: global and local environmental degradation; poverty and fast population growth; geographically shifting and widening economic disparities, with existing tools and paradigms. New tools and paradigms need to be designed, and are being designed. This study is part of an ongoing effort at the International Institute of Applied Systems Analysis, to develop one such tool. This tool aims to analyze population, development, and environment interactions: the PDE-approach.

The approach was first suggested by Lutz (1989, paper). The PDE-approach is 1) empirical, based on case studies, and 2) holistic, including history, present, future, population, socio-economic factors, and the environment.

Case studies are necessary, Lutz argues, because

> ... only concrete empirical evidence, presented in a broad and unambiguous framework that both the social and the natural scientists can accept, will prepare the grounds for a common understanding across disciplines. To gain such common grounds in the global population-environmental debate, it is essential to have well-studies cases to refer to. Especially when the global debate is as confusing and ideological as the present one, an analytical approach developed for a specific case study (such as the model presented in this book) may well help to serve as a guideline for the global discussions. [Lutz, 1994:2]

The subject matter of the PDE studies is the population, development and environment, which are envisioned as three concentric circles.

> The first letter in PDE refers to population; the second, to development; and the third, to environment. This sequence is not arbitrary: it expresses the basic philosophy of the model. Population is taken as the point of departure as one of the basic driving forces that – together with many other factors – has an impact on development within environmental constraints ...
>
> Rather than viewing population-environment linkages in terms of linear causal chains, it should be visualized as a series of concentric circles where the sphere of development, i.e., the sum of social, economic, and cultural activities, is intermediate between the demographic aspects of the human population and the natural environment. [Lutz, 1994:210-1]

The studies rest on two tiers of research, namely: an historical analysis of the case country with qualitative and statistical detail; and a simulation model, which is used to make an historical scenario and future scenarios of the case country. This approach combines the detail, and the nuances which are visible to the human mind's interpretation of a field of facts, and the mathematical consistency that the computer contributes.

The first case study was a four-year project on Mauritius. This study, which is on Cape Verde, is an extension of that approach to a second case study, to analyze whether the population and environment interactions in a different setting are different, or the same.

The motivation to do this second study is to further substantiate or elaborate differently, the general conclusions found in the first study on Mauritius. It aims to describe and analyze the dynamics of: how population change leads to economic reaction; how economic activities are shaped and/or constrained by the natural environment; how the environment influences the population and its society. It further aims to summarize these interactions in a simulation model which is adapted from the version made for Mauritius. It hopes to locate important dynamics which will influence the future of Cape Verde in particular, and global population in general. It is hoped that the study will provide useful information and insights for those who make and advise on policy in Cape Verde.

This second study is the author's doctorate thesis, written in fulfillment of the requirements of the Institute of Statistics, Faculty of Social and Economic Sciences, at the University of Vienna, Austria.

1.2 Basic PDE-approach

Population and age structure, it has been argued in various studies, lie at the base of diverse changes in society: the level of conflict; the rate of technological change; social adaptation; increasing poverty and environmental degradation, to name a few. Different population sizes in a given region, or, population densities, make various forms of society possible, or, it is argued, necessary. An increase in density through population growth can lead to conflicts that need to be resolved with a new social organization (e.g., Cohen, 1974; McNeill, 1990), or new technology (e.g., Boserup, 1968; Jacobs, 1969), or can lead to degradation and, in the worst case, catastrophic events (e.g., Ehrlich, 1971; Forrester, 1971; Abernethy, 1993). Age-structure has also been shown to shape socio-economic events – e.g., in economic growth (Coale and Hoover, 1957), in conflict (Choucri, 1974), or in welfare crises (Prinz and Lutz, 1991).

People are the basic unit of demand for social and cultural services, economic products, and natural resources (whereby the level of that demand per person varies enormously in today's world).

For these reasons, population is the core of the PDE-approach.

The second circle of the PDE-approach is development, which encompasses society, culture, government, and the economy, or, all activity of the population. In this circle, relevant theories and literature are about economic growth (e.g., Kuznetz, 1965; Todaro, 1981); the role of education (e.g., Schultz, 1965; Blaug, 1979); geographical distribution of economic activity (e.g., Knox and Agnew, 1984; Crosby, 1986) and other topics such as women's status, democracy, health care. The economy and society can be seen as topics of their own, but the active agents are always people. Therefore, the socio-economic circle encompasses the population.

Similarly, economy and society themselves are encompassed: all activities take place in an area, a space, and environment. This environment dimension is the third circle of the PDE-approach. The environment is strongly linked with the economy, which extracts raw resources from it, and deposits effluents in it (e.g., Leontief, 1971; Dorfman and Dorfman, 1972). Less obviously encompassed by the environment are "non-material activities" such as governance through dictatorship or democracy; provision of education; status of women: cultural values proscribing certain behavior. Yet, such non-material aspects of the population's activities mediate the manner in which the natural environment is valued and treated (e.g., Douglas and Isherwood, 1979; Pitt, ed. 1988; Hodgen-Norge, 1991; Henderson, 1991; Redclift and Benton, 1994).

The dynamics of how the natural environment reacts to people's activities is a subject of natural sciences, such as ecology, biology, geology, hydrology.

PDE maintains these three areas separate and approaches them with existing tools and concepts, but it combines them all into one study. The combination of the separate parts in one project will make connections and dynamics obvious that are only apparent when one sees the whole.

1.3 The Choice of Cape Verde

The choice of Cape Verde rises from different motivations that of Mauritius. Mauritius was chosen as the first case study because of:

> ... the environmental isolation of this mid-Indian Ocean island, the extremely high population density, and especially the broad availability and generally very high quality of statistical information on most demographic, economic, and environmental aspects. Another important reason for choosing Mauritius was the presence of a competent local team of scientists at the University of Mauritius that was willing to collaborate closely with IIASA ... [Lutz, 1994:5]

Furthermore, the success story of Mauritius with its rapid fertility decline and similarly rapid economic growth provided potential "how to" answers for other countries yet aspiring to this success.

Cape Verde, like Mauritius, is an isolated island in which all environmental change which is not global is caused within the system itself. It thus also lends itself to a "laboratory experiment" study of the effects of population on development and the environment and vice versa.

Cape Verde, like Mauritius, is a country which has the blessing of a responsible government that invests constructively in the health, education, and material and legal infrastructure of the country. A responsible, democratic government was found to be one of the key elements in the success of Mauritius. To choose a country with a repressive or corrupt government would have indicated a study with concerns that outweighed the central questions to be addressed on population, development, and environment.

However, unlike Mauritius, Cape Verde is a country of still high population growth and high levels of poverty. In this, it resembles Mauritius the way it was in 1960. This is precisely the motivation for choosing Cape Verde: namely to see to what extent the general conclusions of the Mauritius study are also applicable to a country which is in a more difficult population and economic situation.

Cape Verde is also an interesting extreme case. It is a country of extreme resource poverty: little water; little easily cultivable soil; virtually no non-renewable resources of market value. One of the country's adaptations to this has been an extremely high rate of emigration and remittances. The consideration of emigration and remittances in this extreme case could provide general insights into the role of these adaptive measures in countries where they are less pronounced and the effects difficult to measure.

Furthermore, Cape Verde is one of the case studies for an UNDP program on long-term future scenarios in Africa. A team of researchers who could advise this study and use its results was present in the country. Cape Verde is also one of the countries selected by Austria – where this study was done – for a concentration of its development aid, and the Austrian expertise was instrumental in the beginning of the study.

The quality of systematic data collection is not exceptionally high on Cape Verde, but the country provides a large amount of reports on diverse topics by the government and by and for the large number of aid donors.

1.4 Structure of the Study

The study is built up of a group of chapters, 2–6, which are an historical analysis of Cape Verde, and a second group, chapters 7–9, which discuss conceptual models, the PDE-model, and the model scenarios.

Chapter 2 gives a brief political and general history of Cape Verde from the beginning of its colonization in the 1460s by the Portuguese to the democratic, independent country it is today. This chapter identifies some of the factors which have shaped the country, and are still shaping it presently.

Chapter 3 analyzes the three components of population change, mortality, migration and fertility. It makes an analysis of the factors which contributed to mortality decline in this century. Following, it describes the emigration trends, and looks at the cultural and economic role of emigration. The third section is about fertility, and the factors contributing to the country's fertility level.

Chapter 4 is about social factors on Cape Verde, of which education, employment and women's status, and agricultural activity and urbanization have been selected.

Chapter 5 looks at the economic structure of the economy. It begins with an analysis of food production, which is the traditional domestic backbone of the economy. It continues with a number of economic sectors which have been selected for their general importance or their role in exports. The chapter concludes with an overview of macro-economic variables and the external economic relations of Cape Verde.

Chapter 6 is on the environment, and devotes most of its space to various aspects of the water household in the country: the climate and geography; natural water supply; water use; and the provision of water and water management. It concludes with a non-water section on the reforestation program of the country.

These chapters are each concluded with a brief summary of the insights from the foregoing. The chapters build on each other, referring to preceding chapters, and thus follow the basic structure of concentric circles of population, social- and economic development, and the ecosphere. The chapters in general, lack a dominant political component, which has been described in other literature referred to in the text. The importance of politics and in particular, the supportive role of the independent country's government, are clear however, from frequent references to the activities of that government.

The following three chapters are on modeling.

Chapter 7 begins, with a discussion of selected existing conceptual models on the relationships between population, development, and the environment. The sections follow the historical discussion from the end of the 18th century to the present, selecting major proponents of different views, pointing out how historical observations motivated the authors in their thinking, and ending with a comparison of the model with the situation of Cape Verde.

Chapter 8 describes the PDE-model. It begins with a general overview of how the model is constructed, and follows with a technical description of the model equations. These have been partially taken over from the PDE-Mauritius study, and partially adapted to the special case of Cape Verde.

Chapter 9 pulls together the insights from the preceding 7 chapters into scenarios. An historical scenario is made which shows some of the trends in the country more clearly than the historical chapters 2-6. Future population scenarios are described in a separate section. The third and fourth sections of the chapter discuss two clusters of scenarios. One cluster models a growing economy, the "Little Mauritius" scenarios, and the second cluster models almost constant gross domestic product, the "Stagnating Exports" scenarios. A brief summary of the scenario conclusions ends the chapter.

Chapter 10 is the concluding chapter. It reviews the specific case of Cape Verde and generalizes insights.

Chapter 2

Brief History of Cape Verde

The first Europeans on on the Cape Verde archipelago were Portuguese who arrived in 1460 on Santiago island. They found an archipelago uninhabited by humans with fertile soils but very little water, and steep mountainous terrain alternating with lowlands. The moistest areas were large mountain valleys that collected water in their floor. The Portuguese chose the mouth of one of the largest and most fertile valleys, in the south of Santiago to settle. They called the valley and the town at its mouth, which became the colony's capitol, Ribeira Grande. The first colonial arrivals were Portuguese, and Spaniards, who were soon supplemented by slaves from the West African coast (Carreira, 1982:4). In the course of the next centuries, nine of the ten islands were settled.

When the Cape Verde islands were discovered colonialism had not been invented. Yet, it was obvious that since the islands were uninhabited, they belonged to the Portuguese Crown and their exploitation should be to the benefit of that Crown. The Crown did not administer its new islands itself, but rather distributed rights to use the resources on the islands against fees.

The strategic position of the islands on the route between Europe, Africa, and Brazil induced the Portuguese Crown to give the settlers special rights. Among the most precious was the trading monopoly along the West-African coast between Senegal and Sierra Leone (Davidson, 1989:25).

The early island economy flourished on the slave trade. Slaves were brought from Africa, "acclimatized" on the isolated Cape Verde islands, and after a domestic slave population had been established, shipped onwards to the Americas. The slave traders paid the Crown taxes. Other resources which were traded and taxed were orchil, and agricultural products for own use and to the passing ships. Cotton was grown and woven; cattle raised; whales caught and boiled and cut; salt panned; and food crops raised.

The land on the islands was distributed by the Portuguese Crown in mostly large units based on the Portuguese *vinculo.* This meant that the rights to use the land were "a form of inalienable, indivisible property, transmitted in the male line by primogeniture ... and the holder of the vinculo at any given time was no more than the administrator of the goods that composed it" (Carreira, 1982:5). This type of administration – which is less conducive to long-term investments than actual ownership might be – may explain in part the agricultural practice of non-investment which developed and which will be discussed in chapter 5 on the economy.

Carreira describes the economy in the early colonial era:

> At first African grains and root crops were cultivated to support the precarious subsistence economy. Maize was introduced from America at the end of the fifteenth or beginning of the sixteenth century and became the staple food crop. Cotton and sugar cane were planted. Cattle were reared for their meat, and for milk, particularly as cheese, and other by-products – hides, skins and tallow. Orchil, a lichen which produces red dye, was gathered ... and indigo ... Salt was collected. Incipient industries were – the manufacture of unrefined sugar and sugar-cane spirit, "country soap", and the woven country cloths worn by the poor and also traded overseas ... [Carreira:6–7]

The free (black and white) population grew from 162 in 1513, to 1200 in 1549, to 2000 in 1582. The first count of the slave population was 13700 in 1582, which possibly includes slaves who were only temporarily on the islands for "acclimatization" before being brought to the Americas (Carreira, 1985:7-8).

Thanks to the trade (mostly slaves) which developed, the islands prospered and by 1549 a report to the Portuguese Crown stated that "apart from Lisbon, no other cities yield as much as Ribeira Grande" (cited in Davidson, 1989:27). But this time of wealth did not last.

The islands' little towns were regularly attacked and sacked by French, British, Flemish, and Dutch. During these uproars, many slaves were able to escape. They moved to the interior of the islands, where they lived from subsistence agriculture in the folds of the hills. These plunderings gravely harmed the islands' economy (Davidson, 1989:28, and Carreira, 1982:23-4). Eventually, the capitol was moved to nearby Praia, which remains Cape Verde's capitol today.

Then, Nature's irreverent tolerance of human life on Cape Verde became apparent: the first recorded famine occurred in 1582-5 (Carreira, 1982:19) and others followed regularly. Regular droughts appear to have been characteristic of the islands at least as long as they have been inhabited. This characteristic made domestic food production insecure, but also may have hindered the development of an export market because production was irregular.

Gradually, Europeans and whites left the islands, or mixed with blacks and slaves. The children of the whites slave owners and black slave mothers were often given freedom. The sons of the white administrators and black slave mothers apparently inherited their father's rights (Carreira 1989:21). The white population diminished – as few new ones came – until it is recorded in 1743 there are "only twenty whites left" (cited in Davidson, 1989:28. The twenty is probably an understatement. There were 243 counted in the census of 1731, 1752 in the census of 1807, 919 in 1869).

In 1731 the population was still only 30387. By this time, the proportion of slaves had decreased dramatically due, among other things, to a decline in the slave trade. There were 5227 slaves, 15528 free blacks, 5804 mestizos, and 243 whites counted (Carreira, 1985:7-8). To these should be added an unknown number living inland in the hills.

Whether because of the own harsh nature of the islands and the recurrent famines; an inefficient monopoly system which restricted international commerce; the repeated pirate raids; or declining slave trade, in the 18th century the economy of the islands began to decline. Some people have blamed the Brazilian *Comphania Grao Pará e Maranhao* which controlled trade from 1758–1778 and hindered or forbade production and export of profitable cash-crops.

Subsequent to the colonial decline, two different nations took advantage of the natural wealth that existed in the archipelago.

For over two centuries, from the end of the 17th, but mostly in the 19th, North American sailors whaled in the profitable waters around the Cape Verde islands. By the time the Portuguese claimed their monopoly rights to the whales in their waters at the beginning of the 20th century, the whales had been all but exterminated (Carreira, 1982:53-4), and the profit fallen in foreign hands.

The poor of Cape Verde took advantage of the whaling by hiring on to the ships. Thus started the tradition of emigration – to the present there are many Cape Verdean descendants in harbor areas around Boston, Rotterdam and Hamburg – which so characterizes Cape Verde even today. These emigrants have been the source of a continuing important flow of income to the country.

In the middle of the 19th century, the British invested in the excellent natural harbor of the island Sao Vicente as a coal depot for ships passing from Europe to the Americas. The harbor and the accompanying town, Mindelo, grew quickly, the town became known as a lively and international spot. In 1884, it was the most frequented harbor on the Atlantic coast of Africa and its revenues made up half of the total revenues of the archipelago. The harbor employed a large number of people in industrial activity, as opposed to the mostly agricultural or artisan activity elsewhere on the islands. Although Mindelo lost its position to the more competitive Canary islands and Dakar, it remains to this day the main center of manufacturing on Cape Verde.

In the 19th century, there were few permanent immigrants to the islands. One of the small groups who came were so-called *degredados* convicts, criminals, and free-thinkers of which 2433 were exiled to the islands between 1802-1888 and most of whom stayed (Davidson, 1989:29). However, one suspects that the influence of foreigners on the economy – the whalers, as well as the administrators and sailors in the Mindelo harbor – affected the Cape Verde population. There are many Cape Verdeans with blond or red hair, and blue eyes, which are probably inherited from other heritage than Portuguese or African. The heritage of the Cape Verde population – dominated by African blood, mixed with all sorts of European – shows all shades of skin color from olive-white to black, hair color from blond to black, and blue, sea-green, and deep-brown eyes, all jumbled together and coming out at random.

In this population, the upper class as well as the majority of the poor of Cape Verde emerged as of mixed blood.[1] A hierarchically higher group of administrators and politicians ruled from far away in Portugal.

The livelihood of a large portion of the people on Cape Verde was not in trade, industry or fishing, but in agriculture. Many authors (Carreira 1982; Davidson 1989; Borowczak 1987; Stockinger 1990) agree that the social organization of agriculture in the *vinculo* and land-tenure system under the Portuguese colonial regime was counter-productive. There was a system of tenancy which ruled out any incentives for long-term farming investments. In 1898, Governor Joao Cesário de Lacerda (quoted in Carreira, 1982) reports on the land tenure system. The plots are:

> generally let out for a year at a time, and the tenants confine themselves to sowing their land with enough to provide them with foodstuffs for their ordinary use. The tenant tries to obtain nothing more, apart from setting aside what has to be paid in rent, since he is neither inspired by incentives nor driven by necessity. This system has many disadvantages and is one reason why the economy of the province is so backward ... Any tenant who improved his land and introduced long-term, extensive cultivation, could be sure that at the end of the year the proprietor would only consent to renew the lease in return for an increase in rent, so that it would be only he who derived any benefit from the improvements.

Comments Carreira:

> It was just the same in 1940, 1950, and 1960. [Correira, 1981:29]

Thus, the 19th century economy was characterized by: a poverty-ridden colonial regime; American whaling in the archipelago's waters; development of the Mindelo harbor by the British; and a large portion of the population employed in agriculture. After the decline of whaling and the Mindelo harbor, the country was sustained in the first half of the 20th century by a decreasing amount of natural good exports (orchil, purgeira-oil nut, castor oil, coffee, salt), by remittances from emigrants, and agricultural production for domestic consumption. The agricultural production was enough to fulfill the basic food needs of the islands' population in most years.

The population in the 19th century grew, from 58 thousand in 1807 to 147 thousand in 1990, and then stagnated. In 1948, the population was 140 thousand. The population movement pattern was characterized by: intermittent famines, high natural growth and emigration. This population movement pattern continued until the 1948. The 19th century pattern is discussed before turning to the modern period below.

Figure 2.1 and *Table 2.1* show the development of the population size from 1807–1992 divided into the period before 1948 and the period 1948-present, which is discussed in the next section.

Famines due to crop failure regularly visited the archipelago, and usually affected one or a few of the islands most severely. Crop failure occurred in years when the tropical convergence

[1]The hue of skin color however, has been a national, racist concern according to the literature, with higher status given to those of lighter skin color. (This point is discussed in Carreira, 1982; Davidson, 1989; and De Sousa Reis, 1989, among others). Although this is no doubt true, data do not indicate in what way people of "light-brown" skin differed from those who were "black" (say, by education, fertility, income, or occupation).

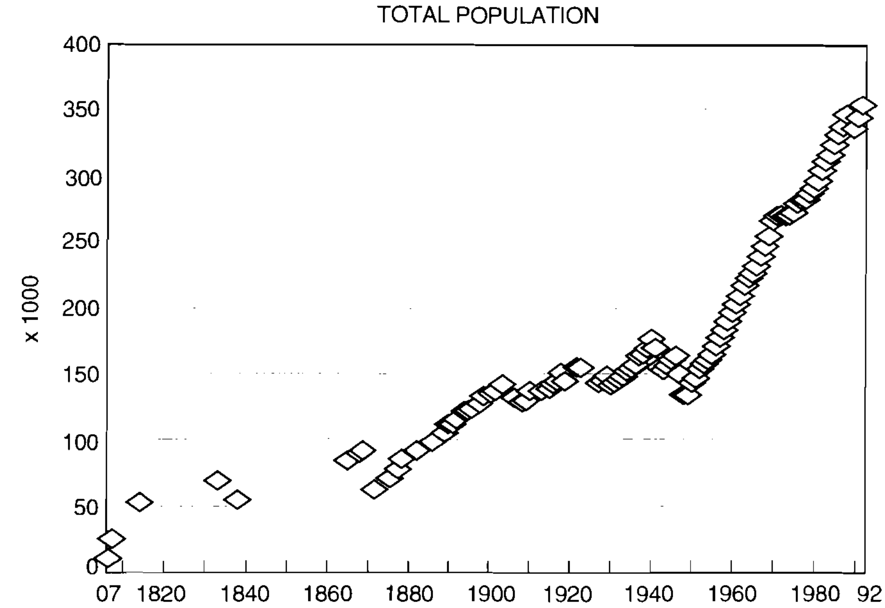

Figure 2.1. Total population size from 1807–1992. Source: Carreira, 1985 and GRE, 1989.

Table 2.1. Population size in selected years from 1807–1992.

Year	Population	Year	Population	Year	Population
1582	15700	1864	97009	1920	159675
1731	30387	1867	67357	1930	146299
1807	58431	1871	76003	1940	181740
1827	74307	1882	103761	1950	148331
1832	60000	1890	127393	1970	270999
1860	89310	1900	147424	1980	295703
1863	94935	1910	142552	1990	341491

did not travel sufficiently north or spent rain on only some of the islands. Usually, not all islands were affected, but because of the travel distances, local crop failure was often not sufficiently compensated with food from elsewhere. A famine in 1830 killed twenty percent of the population – in 1827 there were 74307 people estimated and in 1832 about 60000. The island most affected were Fogo, Brava, and to a lesser extent Santiago and Santo Antao. In Fogo, the population decreased from 12326 to 4000 during that famine and on Brava from 5815 to 2000. An unknown part of this decrease is due to emigration. The consecutive years of famine from 1864-1866 killed almost one-third of the total population on the archipelago. In 1864 the population was estimated at 97009 people, and in 1867 there were 67357 estimated. The hardest hit island this time was Santiago, where the population decreased from an estimated 44200 to 25628. Santiago was also hardest hit in the famine of 1903–1904, and in the famine of 1947–1948.

The suffering and misery of a famine which carries off such large portions of the population is probably unimaginable. Yet, in a very dry and rational way, the famines were concentrations of death which in other countries was spread fairly evenly over the years, with deaths occurring regularly from infectious diseases such as malaria, cholera, typhoid, the plague, and other epidemics which *did not* occur on Cape Verde at least, none are recorded.

In periods relatively free of hunger, such as the periods 1832–1864, 1867–1898, 1905–1915, 1930–1939, the data on total population size indicate that the population grew very quickly.[2] *Table 2.2* shows the population size in the beginning and the end of these selected intervals and the implied average annual population growth rates. In the period 1832–1864, the population grew from 60000 to 97000, an average growth rate of 1.5 percent. In the period 1867–1898 the

[2]The data on births and deaths indicate much lower natural growth. This is discussed in Appendix A.

Table 2.2. Population size at the beginning and end of selected hunger-free periods in this and the last centuries, and implied average annual population growth rates. Source of population size: Carreira, 1985.

Interval	Population in first year of interval	Population in last year of interval	Average annual growth rate (%)
1832–1864	60000	97009	1.5
1867–1898	67357	142537	2.4
1905–1915	134193	156140	1.5
1930–1940	146299	181740	2.2

data imply an average growth rate of 2.4 percent. In this century, it grew 1.5 percent annually from 1905–1915, and between 1930 and 1939, the population increased on average 2.2 percent annually. It should be noted that none of these periods is recorded as a time of immigration, on the contrary, 1905–1915 was a period of very high *out*-migration.

If the population size data are reasonable, they indicate a very high natural increase outside of famines. Carreira attributes this to a very high birth rate. They also indicate that in non-hunger years, the living conditions on the islands were comparatively healthy.

Characteristic of these years, as mentioned above, is that the people of Cape Verde were emigrating throughout the whole period under discussion here – mostly to the United States. It is suspected that emigration began at the end of the 17th century (Carreira, 1982:42) when Cape Verdeans boarded foreign whaling ships fishing in the rich waters of the colony. Emigration would have started slowly, as Cape Verdeans came in contact with the (mostly American) whalers, and increased as Cape Verdeans settled in the United States and could encourage friends and family to also move. Data on emigration are only available for the twentieth century. Carreira estimates that from 1912-1973, 196 thousand Cape Verdeans left their country voluntarily; 81 thousand were forced to emigrate between 1902 and 1970; and 80 thousand returned between 1933–1973 (Carreira, 1982: 201-14).

The emigrants sent remittances to Cape Verde, but some of them also returned to the archipelago with their savings. These re-migrants bought land from the impoverished traditional land-owners since the vinculo system had ceased to exist. This exchange of property caused a shift in wealth from old families to new ones, but did not basically alter the economic system of Cape Verde (Carreira, 1982; Davidson, 1989)

In 1947–1948, there was a large famine during which the population declined by 17 percent. This was the country's last famine until the present day, although there have been periods of drought since those years. The reason there has been no more famine is because *food was brought to the country.* The imports of food and other goods in the 1950s and 1960s were financed by emigrants sending home remittances; by social security payments of retired Cape Verde workers who received a pension from the United States; and by help from the Portuguese government. These "invisible earnings largely covered the balance of payments deficit" (Carreira, 1982:35).

The Portuguese started some programs of development. One of them was the *Apoio* system, which employed destitute rural population on public works, mainly road building. These programs employed a quarter of the work-force in the 1950s. They also began some reforestation programs.

In this period, the desire for political independence from Portugal, historically following the world trend of de-colonization but with its roots in the beginning of this century (De Sousa Reis, 1989), developed into a war of independence, which began in 1960. Cape Verde and Guinea Bissau joined forces in this guerrilla war of independence which was fought on the African mainland in Guinea-Bissau. The ideological leader of the independence movement was Cape Verde born Amilcar Cabral (1921–1973), whose ideas shaped Cape Verde's government policy in the first decades of independence and still influence the country today. The ideology was a form of grass-roots socialism designed to empower the people of Cape Verde and Guinea Bissau in their own culture and environment.

The war lasted until 1974, and ended simultaneously with the overthrow of Portuguese fascism. From 1975 to 1981, the Cape Verde was one country with Guinea-Bissau. After the military coup in the latter, the two regions split into separate republics. Cape Verde was governed by the *Partido Africano Independente do Cabo Verde* (PAICV) in a one-party, socialist system until 1991. The PAICV was a pragmatic party, which made friends with communist and capitalist countries alike. It developed its own form of participatory socialism which entailed many grass-roots meetings and discussions to decide national or regional policy. The economy under the PAICV government emphasized: increasing education; reducing mortality; improving the agricultural system by changing the land ownership and tenancy laws; and building up the basic infrastructure to conserve land and water by recycling funds obtained from abroad in food-for-work programs.

Foreign aid arrived after the change in Cape Verde's political status. As an independent state, money from abroad arrived in greater amounts. There was also a big increase in service exports, in maritime and air traffic as well as telecommunications. The country's economic policy, says the World Bank (1992), was inward looking, seeking mainly to produce for the local market. All of this allowed the country to survive the major drought, which swept all of West-Africa in the 1970s, without famine.

Without famine, with its traditionally high natural growth, which was probably augmented by hygienic measures, better food and imports of medicine after 1948, the population size of the country grew faster than it ever had before even in good years. From 1950–1970 the population increased from 148 thousand to 271 thousand, which implies a three percent average annual increase. During the 1970s, population growth was lower. This was due to two factors: emigration during the drought years; and a very small cohort of women in child-bearing ages.

The women born in 1940–1949 were in their prime child-bearing age during the 1970s. This group of women was very small, because of the effects of two famines (1941–1942 and 1947–1948) during which infant mortality was about 25-50 percent and the birth rate was much lower than in normal years. In the 1970s, births were dominated by this small group of women. Slowly, this group has been moving out of the child-bearing ages and replaced by "normal" sized cohorts, which are much larger.

Increasingly, as the population has grown, buoyed by remittances and foreign aid, Cape Verde has become "independent" of its environment. Even if the agricultural sector was able to provide for the population in relatively good years up to 1948, the environmental constraints on growing food for the new sized population are so overwhelmingly great that they – disappear through other solutions.

After a large increase in the economy in the first decade after independence, the economy stagnated. Since 1984 the real value of public transfers and aid has been decreasing. The value of service exports has leveled off to a constant real level since 1980. This might be a reflection of the increasing inefficiency of public enterprises posited in some literature (e.g., World Bank, 1992; Bundeskanzleramt, 1993; Economist, 1994) but might also be because service exports are tightly correlated with foreign aid. At the same time, emigration decreased as the industrialized countries restricted their inflows of foreign workers.

Parallel with the economic stagnation; with renewed population growth as emigration diminished and the small famine cohorts in child-bearing ages were replaced by large ones; the country introduced a family planning program in 1984. This program had 55 centers in 1994, which means the centers-per-women density is higher than in other countries which have had very successful family planning programs, such as Mauritius. The fertility level of Cape Verde has decreased since the introduction of the program from around 6 children per women to 5.

In reaction to the economic stagnation, the government announced a change in policy in 1988 to a more outward looking economy. The ingredients there-of are to: privatize public enterprises; to liberalize the economy; to promote foreign trade. In 1991, the country had its first democratic elections, in which a new party, the *Movimento pará Democracia* (MPD) was voted into power. The new party and government pursue the same goals of moving towards a market economy.

The economy that emerged in the early 1990s is one in which the primary sector is the largest employer – agriculture, pasturage, and fishing – and provides mainly for domestic needs, but falls far short of making the country food self-sufficient The products are distributed by an informal market network of *rabidantes*, or market women. A small portion of primary products is exported. The public sector dominates in the provision of services, investment, and in construction works. The public sector was estimated at 47 percent of GDP, in 1990. Other productive sectors independent of the primary and the public sectors, such as manufacturing and tourism, have remained fledglings so far in the independent Cape Verde economy. There are promises that these sectors will grow in the near future. Economic growth is squeezed by geographic location and water availability, but also by a labor force with a lower level of education than in many other developing countries. However, the large inflow of foreign transfers has been well-used to build an infrastructure of roads and harbors which is a capital base the country can build on. The population on the other hand, particularly the working age group in the population, is growing very quickly and will continue to grow for the next decades at least, which provides a need to provide jobs.

How Cape Verde can succeed in strengthening its economy, and become more independent of aid, what the population growth will be, and how the environmental constraints will affect the country in the future is on of the topics of this study, to which chapter 9 on scenarios will return. The next chapters 3-6 analyze the historical population, the socioeconomic development, and the present environment of Cape Verde in more detail to identify patterns relevant to the future study, and to the questions of population, development and environment.

Chapter 3

Population of Cape Verde

3.1 Introduction

The previous chapter on history showed the growth of population on the Cape Verde archipelago. In the 19th century population grew from 58 thousand in 1807 to 147 thousand in 1900. This growth was due to high natural increase in non-famine years tempered and regularly set back by famines. It was also moderated by emigration. In the first half of this century, this pattern persisted, but no longer resulted in population growth. In 1948, just after one of the major famines of this century on the archipelago, the population was only 140 thousand people. To some extent, the stagnation of the population size was due to (possibly increased) emigration, which was estimated to be on the order of 60 thousand net in the first half of the century (Carreira, 1982:201-14, but with years missing).

After 1948, food was brought to the country, financed by various means, which eliminated famine, and perhaps malnutrition. This, together with perhaps the introduction of hygienic measures and medicine, reduced mortality which with constant fertility resulted in a surge of population growth. From 1950–1970, population growth averaged 3 percent annually, and in 1970 the population size was 271 thousand. In the 1970s, this natural population growth was moderated by the largest flow of emigration recorded in this century, and by a low number of births due to the small size of the cohort of women in child-bearing ages. In the beginning of the 1980s, emigration decreased and population growth returned to the 1950–1970 rates. Since 1970, fertility levels have also declined, but slowly.

This chapter analyses the factors that affected these shifts in mortality, emigration and fertility.

The high levels of natural growth in between famines indicate that the population of Cape Verde had relatively high survival rates absent of hunger. How much did the famines reduce average life expectancy? And, how much did improved diet once famines were eliminated increase life expectancy? Additionally, infant mortality is discussed, because Cape Verde has lowered this rate from very high levels to one of the lowest in Africa. A model is presented which calculates the increase in life expectancy at birth due to declines in famine, diarrhoeal diseases, and infant mortality.

Emigration is calculated and the number of "Cape Verdeans" abroad as presented in the literature is evaluated. This is connected to the trend in remittances from 1973–1988.

Fertility is discussed and the historical data are compared with model estimations. It is found that the model estimates different levels of fertility than are provided by the data. Fertility is discussed in connection with contraceptive use, urbanization and education.

The result of this analysis is insight into the population dynamics of Cape Verde in this century which may provide useful insights for scenarios of future population development. Additionally, an evaluation of the existing population data of the country emerges.

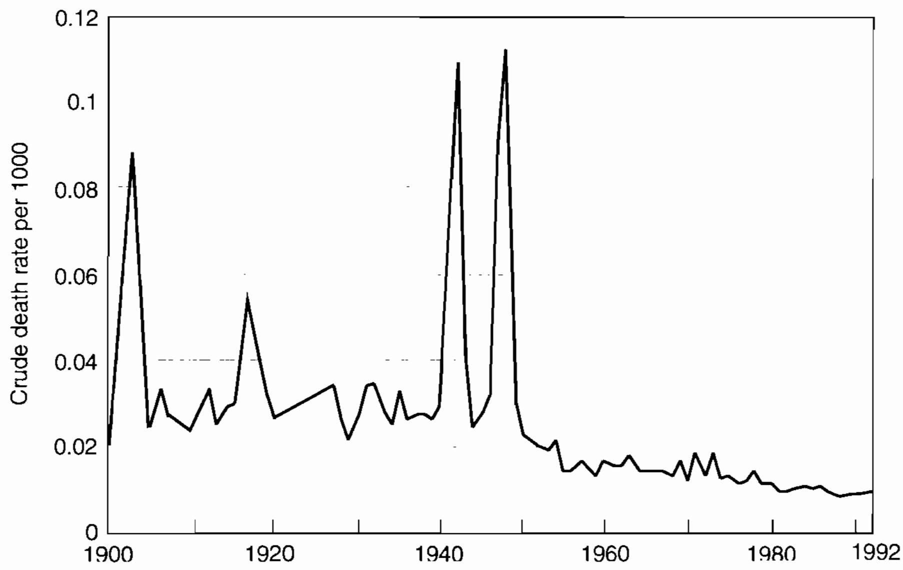

Figure 3.1. Crude death rates in Cape Verde from 1900–1992, according to national sources.

3.2 Mortality

Figure 3.1 shows the crude death rates for available years from 1900–1992. The crude death rates until 1948 show regular peaks of famine, which are extreme. In the "normal" years, crude death rates fluctuate. There is no discernible trend in the "normal" death rates in the period from 1900–1948, as there was in Mauritius, where crude death rates declined slowly but regularly throughout the first half of the century.

From 1950 crude death rates drop quickly until 1955, and then slowly and continuously. The average life expectancies are estimated to have increased from 49 for men and 50 for women in 1950–1955, to 58 and 62 years in 1970–1975, and are estimated to be 68 and 69 years by the United Nations (1993), in the period 1990–1995.

This section estimates life expectancy before 1948 with and without famines. Then, taking the UN life expectancy for 1950 as a base, it estimates how much of the life expectancy increase since 1950 is due to drastic decreases in diarrhoeal disease and infant mortality.

3.2.1 The mortality transition – from high to low mortality

In the period 1900–1990, Cape Verde moved from a situation of high mortality and low life expectancy, to one of low mortality and high life expectancy at birth. This transition is the same as observed in many other populations during this century. It is the result of changes in the timing of death but also, a change in the dominant cause of death. The change in causes of death is so great that one can speak of an *epidemiological transition*. In the original phase of this transition, most death is caused in infancy, and by infectious or deprivation diseases which occur in all ages. In the second phase of the transition, the above three types of causes of death are greatly reduced, and the dominant cause of death are the chronic, degenerative diseases such as cardiovascular diseases, cancer, cirrhosis, which occur almost exclusively at higher ages. It may be that there are later phases which we have yet to reach. Cape Verde has largely finished the first transition and its population presently enjoys a high life expectancy. Evidence shows that a very large part of this change is because of the reduction of deprivation diseases, which on Cape Verde were related to diet.

Throughout most of human history, frequent and early death was the rule. From the data that exist on past death rates it appears that death in the first year was very common – 10 to 20 percent of new-born infants died. Death from infectious diseases dominated the rest of the picture – cholera, pest, malaria, typhoid fever, dysentery, TBC, smallpox. In some areas and periods, diseases related to malnutrition brought a large portion of deaths – these are diseases such as beriberi, scurvy, and enteritis. Thus, there were three groups of causes of deaths that dominated in the past: infant mortality, infectious diseases, and deaths related to deprivation, or poor health. Infectious diseases are those which are carried by bacteria or viruses and *which can lead to disease in whoever becomes infected by the organisms.* The chances of survival are, of course, better for a person with a healthy constitution. Diseases of deprivation on the other hand, *affect those who are in poor health.*

When mortality drops from this situation, as the result of better health of the population, public measures, or better medicine, infant mortality, deaths from infectious diseases and deaths from deficiency diseases decrease.

Because these deaths, which are often at a young age, are eliminated or decreased, people live on average to an older age. At older ages, people die of different causes, namely, chronic degenerative diseases or simply from old age. What has happened in many countries which have passed the epidemiological transition is that the chronic degenerative diseases have increased enormously. There were years in the 1970s when life expectancy for men in some countries was decreasing because of the surge in heart diseases. Studies have related chronic degenerative diseases not just to age, but also to the modern lifestyle: stress, fatty diet, little exercise, smoking, alcohol, are the most frequently named factors. In Cape Verde, it is almost impossible to say if chronic degenerative diseases now dominate death, because statistics on cause of death are insufficient. As recently as 1987, 37 percent of all deaths fell into the "badly defined" or "other diseases" category.

There are those who argue that chronic degenerative diseases too can be reduced, which will increase life-expectancy further to a third epidemiological phase, where most people die naturally of old-age (see, e.g., Duchene and Wunsch, 1991 or Manton, 1991). However, that discussion is not relevant to this study on Cape Verde.

Cape Verde has a relatively healthy climate and epidemics of infectious diseases such as malaria, cholera, typhoid, pest, flu, etcetera were not major killers as in many other tropical countries. The main reason is probably that the climate on Cape Verde is dry, and not conducive to the growth of many types of disease organisms.

3.2.2 Recreating the mortality and life expectancy pattern on Cape Verde 1900–1948

Mortality in the period 1900–1948 was high, irregular, and does not show any trends in decline, as shown in *Figure 3.1* and *Table 3.1*. This section estimates the average life expectancy in that period, first *excluding* famine deaths, and then including famine. The reason for excluding famines in the first estimation is that famine years were atypical years of mortality and do not give a correct impression of what average mortality conditions on the islands were like. Second, because famines were irregular in timing and intensity, their inclusion introduces a large margin of statistical uncertainty for the calculation of an average.

The statistical situation of the period 1900–1948 is that there are crude death rates and infant mortality rates available for a large number of years, as well as total population. Age-specific data on deaths and population size are not available. This information alone is insufficient to estimate life-expectancy.

In order to overcome the limits imposed by such data scarcity, Coale and Demeny (1983) developed a set of so-called model life-tables, which represent typical patterns of mortality. These model tables can be used to make mortality estimations when data is missing or suspected to contain large error.

Coale and Demeny produced four "families" of model life tables North, East, South and West, based on four patterns of mortality observed in Europe in this and the last century. They

Table 3.1. Crude death rates from 1900–1948, all available years.

Year	Death rate	Year	Death rate	Year	Death rate
1901	n.a.	1918	n.a.	1934	0.02373
1902	n.a.	1919	0.03018	1935	0.03166
1903	0.08724	1920	0.02528	1936	0.02516
1904	n.a.	1921	n.a.	1937	0.02624
1905	0.02324	1922	n.a.	1938	0.02608
1906	0.03205	1923	n.a.	1939	0.02487
1907	0.02566	1924	n.a.	1940	0.02824
1908	n.a.	1925	n.a.	1941	0.08004
1909	n.a.	1926	n.a.	1942	0.10942
1910	0.0229	1927	0.03296	1943	0.04072
1911	n.a.	1928	0.02475	1944	0.02333
1912	0.03225	1929	0.01984	1945	0.02671
1913	0.024	1930	0.02599	1946	0.03125
1914	0.02817	1931	0.03285	1947	0.0905
1915	0.02863	1932	0.03328	1948	0.11288
1916	0.0518	1933	0.02681		

> suggest using the West family in the circumstance of underdeveloped countries where there is no reliable guide to the age pattern of mortality that prevails. The other families can be moderately useful in these circumstances to illustrate the variability in estimates that arises from assuming well-established age patterns other than the pattern underlying the West tables. [Coale and Demeny, 1983:25]

Each family of life tables is a series, each member of the series showing the same pattern of mortality by age, but different levels. The different levels correspond to different life-expectancies. Once a student has chosen which family to use, *every given age-specific mortality rate is unique to a certain life-expectancy.* The total crude death rate is not unique for every life expectancy level because it varies with different birth rates (higher birth rates imply a younger age-structure which leads to different crude death rates than an older age structure). To estimate life expectancy with the model life tables an age-specific death-rate is needed, or crude death rates and gross reproduction rates.

The Cape Verde data do not provide data on the gross reproduction rate. They do provide one age-specific mortality rate, namely infant mortality rates for most years of this period. Infant mortality may have been under-reported, because many infants which were born and died quickly were probably never registered, as a birth or as a death. The average registered infant mortality rate from 1912-1948 in non-hunger years was 198 per 1000 live births. Using the West life table, this corresponds to so-called mortality level 8, with life expectancy 38 for women and 37 for men. This is relatively high compared to other tropical countries at that time, but it may have been somewhat lower, depending on the extent of infant mortality under-reporting.

The choice of life table family with the same infant mortality rate makes a difference to the estimated life expectancy. Using the North, East, and South life tables, the estimated life expectancies are 35 and 32 for women and men respectively with the North; 45 and 42 with the East; and 35 and 34 with the South. The margin of uncertainty, given that infant mortality is correct, is 22 percent using the highest estimate as a denominator.

This average life expectancy in non-hunger years does not include the effect of famines which, in the long run, lowered the average life expectancy of the population.

Life Expectancy 1900–1948 Including Famines

A person born on Cape Verde before 1948 had a high chance of experiencing at least one and, given survival, a number of famines during his or her lifetime, each with a high risk of dying. From the point of view of a baby this increased the risk of premature death, in other words: lowered life expectancy at birth.

During the famine years, deaths were counted, and records exist of the crude death rates and the infant mortality rates. The registrations indicate that infant mortality was over 50 percent in the worst famine years of this century on Cape Verde (1947, see *Table 3.4*), and that crude death rates were in excess of 10 percent in some years. Both of these data should be considered proximate. Many deaths may not have been reported. The population size, which is the denominator of the death rate, was shrinking quickly during a famine, making calculation of the rate less exact. Many of the infants who died in famine years were neither registered as a birth nor as a death. Keeping these precautions in mind, the data are used as they are given.

The registered average crude death rate from 1900-48 was 38 per 1000 annually including the famine years. Without the famine years 1903, 1916, 1941/2, and 1947/8 the average crude death rate was only 27, which is 25 percent lower (see *Table 3.1*). How much did these rates lower the life expectancy calculated above for "normal" years, during the period 1900-48? For this estimation, it is preferable not to use the Coale and Demeny life tables because it is believed (for reasons mentioned above) that the infant mortality rate was more than "normally" under-registered during famine years. The crude death rate, faulty though it may also be, is used, as it was possibly less incorrectly measured than the infant mortality rate.

The technique used to analyze the lowered life expectancy due to famines is an adaptation of a cause-deleted life table, discussed, e.g., in Keyfitz (1986:48-52). With the cause-deleted life table, the student can calculate what the life expectancy of a particular population would be if all mortality remained the same except that deaths from one cause were eliminated. For example: What would life expectancy on Cape Verde be if bronchitis and other respiratory deaths were eliminated? Or: What would life expectancy in Austria be if cardio-vascular disease were eliminated?

It is argued in Appendix B that one can use the same technique to calculate what the life expectancy of a population would be if a cause of death were *added*. In this particular case: How much would the estimated life expectancy on Cape Verde in 1900-48 be lowered by adding the famine deaths? Other, more timely applications of the *cause-added life table* would be to calculate, e.g., the effect of increasing deaths from AIDS or the resurgence of malaria. Appendix B discusses the mathematics of the cause-deleted, the cause-added, and a second adaptation to be discussed in the section below, the cause-decreased life table.

Using this technique, and assuming that the relative increase of mortality was the same in all age-groups, the life expectancy from 1900-48 including the famines which occurred in that period, was estimated. *The estimated life expectancy for these 48 years including famines was 31 years for men, and 33 years for women.* In other words, in the period 1900-48, with famines life expectancy is lower by 6 years for men and 5 years for women compared to the Coale-Demeny model life table estimation above.

3.2.3 Decreasing mortality 1948–1992

After 1948, famines ceased, crude death rates decreased, and life expectancy rose quickly in Cape Verde as in many developing countries at that time (see, e.g., Keyfitz, 1988). By 1950–1955, the United Nations (1993) estimates life expectancy was 49 years for men and 50 years for women, already much higher than the non-hunger average estimated for 1900–1948. Some part of this is probably due to different data and estimation methods used, but some part is probably real. Twenty years later, in the period 1970–1975, the life expectancy was estimated to be 58 for men and 62 for women. Again 20 years later, in the period 1990–1995, life expectancy was estimated 68 for men and 69 for women by the UN. These life-expectancy estimates are compared with ones found using the model-life tables and infant mortality rates; and with ones found using the national age-specific mortality data, which are available to 1970/1 and 1990. The results are shown in *Table 3.2*. The first column of estimates contains those of the United Nations; the second column the model life-table estimates; and the third the results using national age-specific mortality data.

Table 3.2. Life expectancy at birth in Cape Verde for men and women according to three estimates from different sources for 1950, 1970, and 1990.

	United Nations, 1993		Coale and Demeny model life table West family		National data	
Year	Men	Women	Men	Women	Men	Women
1950 (1950–1955)	48.5	50.0	49.5	52.5		
1970 (1970–1975)	57.5	61.5	51.8	55.0	55.1	56.6
1990 (1990–1995)	67.8	68.7	63.6	67.5	66.6	73.6

Table 3.3. Age-specific mortality rates according to national data in 1970 and 1990 for men and women by five year age groups. Sources: Secretaria, 1984 and unpublished statistics, Direccao d'Estatistica.

Age	Women, 1970	Men, 1970	Women, 1990	Men, 1990
0–4	.0368	.0397	.0100	.0143
5–9	.0033	.0030	.0006	.0006
10–14	.0020	.0017	.0004	.0004
15–19	.0025	.0018	.0006	.0008
20–24	.0030	.0020	.0005	.0015
25–29	.0034	.0023	.0008	.0034
30–34	.0039	.0028	.0020	.0042
35–39	.0043	.0036	.0018	.0051
40–44	.0049	.0047	.0034	.0056
45–49	.0058	.0064	.0047	.0061
50–54	.0073	.0092	.0028	.0109
55–59	.0102	.0137	.0063	.0147
60–64	.0155	.0210	.0080	.0135
65–69	.0266	.0352	.0168	.0171
70–74	.0458	.0617	.0294	.0397
75+	.0768	.1061	.0302	.0547

The estimates by the three sources all differ somewhat, but seldom more than ten percent. In 1950, life expectancy at birth was around 50 years according to both available sources. In 1970, the estimates disagree more strongly. The model life-table estimates are clearly lower than the other two estimates for men. The United Nations estimate for women's life expectancy at birth is clearly higher than the other two sources. Choosing a different model life table, namely East, would bring the model life-table estimates into the same range as the other two, namely 53.7 and 57.5 years. All three sources however, that life expectancy increases were about equal from 1950-1970 as from 1970-1990. Life expectancy for men in 1990 was around 65 years according to the three sources, and around 70 years for women. The national data estimate for women appears very high.

Table 3.3 shows the age-specific annual mortality rates for men and women in 1970/1 and 1990. The child mortality rate estimated for women in 1990 is very low compared to that of men (40 percent lower). If this were adjusted upwards, the life expectancy of women would be closer to the UN estimates.

Infant Mortality Decrease

Infant mortality decreased to only 41 per 1000 live births in 1992, which was the lowest rate in all of Africa except Mauritius, including South Africa and the Maghreb countries. *Table 3.4* shows the infant mortality rates for available years from 1912-1992. Infant mortality rates dropped down around 1950 – to levels around 100 down from previous levels around 200 – and then declined further sometime in the 1970s and 1980s. After independence, the government and international agencies invested much in lowering infant mortality.

Table 3.4. Infant mortality per 1000 live births in available years from 1912–1992.

Year	IMR	Year	IMR	Year	IMR
1912	221	1962	106	1983	64
1913	174	1963	110	1984	59
1915	118	1964	85	1985	68
1920	155	1965	77	1986	66
1927	218	1966	84	1987	62
1931	207	1967	100	1988	51
1937	223	1968	92	1989	n.a.
1943	318	1969	123	1990	n.a.
1945	200	1970	95	1991	n.a.
1946	269	1971	131	1992	41
1947	523	1972	91		
1948	429	1973	111		
1949	204	1974	79		
1950	131	1975	104		

An estimate is made how much the reduction of infant mortality contributed to life expectancy increase from 1950-1990 by inserting the 1990 infant mortality rates into the 1950 life table. The 1950 life table is estimated by adjusting the age-specific mortality rates of the observed 1970–1971 upwards and recalculating the life table to give the UN estimate for life expectancy in 1950–1955.

With this adjustment, the *infant mortality reduced* life expectancy is 55 years for men and 55 years for women. This means that *the reduction of infant mortality from 1950–1990 added 7 years of expected life at birth for men and 5 expected years of life for women.*

Decrease in Death Due to Intestinal Disease

The increase in life expectancy from 1950–1990 due to the elimination or reduction of certain causes of death beyond infancy is difficult to estimate because such a large proportion of deaths is categorized under unknown, ill-defined, or other causes. Nevertheless, there is information about one cause of death which is related to malnutrition and/or unhealthy water, and which was and still is the single largest cause of death besides infant mortality: this is the group of non-infant deaths caused by "gastritis, duodenitis, enteritis, and colitis except for diarrhea of the newborn" (causes 560, 561, and 570 in the 1960 international three digit code).

In 1960, which is the earliest date for which cause-specific death rates were found (United Nations, 1966:485), this group of diseases caused 774 out of 3127 deaths, or 25 percent of the total. Assuming that this proportion was the same in 1950 means the cause specific death rate from diarrhoeal disease in 1950 was .25 * 21.5 = 5.3 per 1000. In 1987, which is the latest year the data provide cause-specific deaths (DGE, 1988), deaths caused by "enteritis and other diarrhoeal diseases" were 325 out of 1393, or 12 percent of total deaths. However, these included infant deaths from diarrhea. According to the UNICEF (1993:48) 28 percent of infant mortality was from this cause in 1992. Total infant mortality was 62 in 1987, out of 12771 births. The number of diarrhoeal deaths in infants in 1987 was about 12771 * .062 *.28 = 222. If this is true then the non-infant diarrhoeal deaths were only 325-222=105 in 1987. Then, the cause-specific death rate compared to the estimated 1987 population of 347060 was only .3 per 1000 persons.

This decrease could be partially due to imported medicine to treat infections, but much of it is no doubt related to better health of the Cape Verdeans. According to the Food and Agriculture Organization (FAO, 1991), the daily per capita calorie intake increased from 1841 per capita per day in 1961 to 2872 in 1990.

There is no age-specific data available for deaths from diarrhoeal diseases. Therefore, the same assumption of "equal relative effects in all age groups" is used as was applied to the elimination of famine deaths above.

The total non-infant deaths in 1950 were 3187-779 = 2408 which gives a non-infant death rate of 2408/148331 = 16.2 per 1000 (including infants in the denominator). This is the actual death. Of these, one quarter, or 602 are estimated to be from non-infant diarrhoeal disease in 1950. This leaves 1806 non-infant deaths from non-diarrhoeal diseases, which provides the fictive non-infant, non-diarrhoeal death rate of 1806/148331 = 12.2 per 1000 (including infants in the denominator). Since not all diarrhoeal diseases were eliminated in the period 1950-1990, the diarrhoeal specific death rate for 1987 is added to the fictive rate, to provide 12.5 deaths per 1000. This is the "cause decreased" fictive death rate in 1950.

Analogous to the procedure used for famine-elimination, the fictive and the actual death rates are used to calculate the *cause-reduced life expectancy*, also described in Appendix B. This life expectancy is 59 years for men and women (it includes the lower infant mortality rates), indicating that *the estimated decline in non-infant diarrhoeal deaths from 1950–1987 raised life-expectancy by four years for men and women.*

3.2.4 Conclusions of mortality analysis

In summary, the analysis of mortality estimated that:

1. The average life-expectancy in the period 1900-1948 on Cape Verde was 31 years for men and 33 years for women.
2. Without famines, the life expectancy in that period would have been 37 years for men and 38 years for women.
3. Since 1950-5, when life expectancy was estimated by the UN to be 48 years for men and 50 for women, the decrease in infant mortality added 7 years of expected life at birth for men, and 5 years for women.
4. The reduction of deaths from non-infant diarrhoeal diseases in the period 1950-1990 added another 4 years of life for men and women.

3.3 Emigration

Emigration has been an important source of population change. The pool of Cape Verdeans abroad has contributed substantially to national income. The desire to emigrate also motivated an education drive in the beginning of this century to fulfill immigration requirements of the destination countries.

The majority of Cape Verdeans on Cape Verde until recently made their living from the sparse land. As discussed above, in good years this afforded a meager existence, and in bad years meant death for large portions of the population. It is therefore not surprising that from the beginning, Cape Verdeans have been leaving their country. In the sixteenth and seventeenth centuries most of the Europeans returned to Europe, although this was a very small group. Another small group went to the African coast where they earned a living as smugglers along the West-African rivers, by-passing the Portuguese Crown's monopoly of trade there. But the flow of emigration which lies at the basis of today's flows probably began later, at the end of the seventeenth century. It was the result of American whaling activities in the Cape Verdean waters.

The American whalers in the Cape Verdean waters would go ashore to cut, boil and otherwise treat the whales, and to obtain fresh supplies of food and water. There, they came contact with Cape Verdeans. It is uncertain when the first Cape Verdeans boarded the American ships to become sailors. Certainly, it became a large movement by the nineteenth century. A number of the Cape Verdeans disembarked from the ships upon arrival in Boston, New Bedford, and other towns in New England, and stayed in the United States. Data on emigration from 1900 collected by Carreira show that in the second decade of this century, emigration was high, and equaled about 10 per 1000, or one percent, annually.

Table 3.5. Population of men and women on Brava, the island most affected by emigration in the last century, in 1867–1878. Source: Carreira, 1982.

Year	Men	Women
1867	2426	3448
1872	3669	4948
1875	2480	4104
1878	3547	4611

One some of the islands, notably Brava, the pattern of emigration of men, sending home remittances, and sometimes returning with savings, while the women stayed at home, became the backbone of the economy. The unbalanced male and female populations on Brava in the middle of the last century are shown in *Table 3.5*. The uneven sex ratio resulted in many women raising children of absent fathers, a family pattern which persists in Cape Verde until today.

Emigration also furthered domestic education via immigration regulations of the destination countries. In the beginning of this century, US immigration laws were tightened. From 1917 only literate persons were allowed to migrate to the United States. This led to an effort in Cape Verde which resulted in about one-quarter of the male population in school age going to school, and perhaps more learning to read and write through other means. Nevertheless, emigration to the United States decreased. This led to Cape Verdeans seeking work in other countries, which was not able to compensate fully for the reduced US market.

From 1921–1945 emigration was lower than in the preceding two decades. It was dispersed to Africa, Europe, Brazil. Since the end of World War II, emigration has been oriented to Europe, first to the Netherlands, then to Portugal, France, Luxembourg, Italy and Switzerland. There was a veritable exodus of Cape Verdeans in the 1970s during the major drought from 1967–1986. This flow also included women. As a result, the total adult population decreased relative to dependents (children and elderly), but the sex ratio in the country remained fairly close to 1. In recent years, emigration has diminished, this time following a tightening of European immigration laws.

Emigration was not only voluntary. Carreira documents the extent of forced migration from Cape Verde to work on the plantations of Sao Tom and Principe. Forced emigration was disguised as the deportation of vagrants. According to the law, all persons were obligated to see to their livelihood, and those who could not do so, were subject to deportation. A quote from the Portuguese Law of 1899 serves to convince incredulous readers:

> All natives of the overseas Portuguese provinces are under a moral and legal obligation to obtain means of livelihood, and to improve their social conditions, by their own labor. They have full freedom to choose how they carry out this obligation: but if they fail to carry it out in some way, the authorities may force them to do so ...
>
> Those subject to the obligation to work who have not carried it out voluntarily by any of the means specified in section 2, shall be summoned by the administrative authority to work in the service of the State, of the municipalities or of private persons ... If they do not obey the summons they will be compelled to do so ... [Cited in Carreira, 1982:112]

In times of economic distress, such as famines, the number of people who were not fulfilling their "obligation to work" was particularly large and in these years, the figures show marked increases in forced emigration. The number of people forced to emigrate was more than 80000 in this century, and many of them as recently as the 1960s.

Figure 3.2 gives the estimated voluntary and forced emigration and voluntary immigration figures from 1900 to 1992. This figure shows that emigration was relatively large in the 1910s, decreased to almost nothing in the 1930s and 1940s, and since that time has increased exponentially, following population growth but also increasing relative to population size. The figure also shows that the immigration curve closely follows emigration (these are numbers of people who

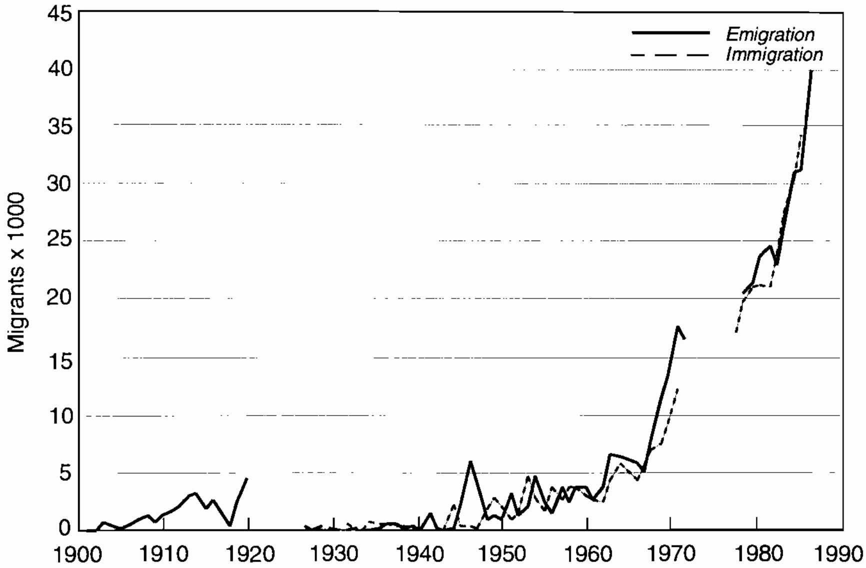

Figure 3.2. Emigration from 1900 and immigration from 1933 to 1990. Source: Carreira, 1982 for 1900–1973; Statistical Office for 1974–1992.

state that they are emigrating and immigrating, not simple passenger numbers), which indicates that most of the Cape Verdean emigration is actually temporary, rather than permanent.

3.3.1 Modern emigration 1970–1990

Migration since 1970 is characterized by: larger absolute and relative flows than those in preceding decades; the participation of women in migration; positive net out-migration for all age-groups up to 65. An estimation of migration interpolated between the census counts of 1970 and 1990 finds: the size of net-migration by five-year period; the age- and sex distribution of the migrants; and evaluates the registered migration data.

The method used is similar to one used in unpublished work for Mauritius (Wils, 1989), and can be called the *cohort component method of migration estimation.* The mathematics are described in Appendix C. Briefly, the method makes an historical population projection from the beginning of the observation interval 0 to the end of the observation interval t, using existing data on the population age structure in time 0 and the age-specific death and birth rates or absolute births in the interval 0 to t. The historical population projection provides the population in time t *if there had been no migration.* The projected population is compared to the actual population in t. The difference between the projected and the actual population is assumed to be the result of migration movements in the interval 0 to t.

Using this method, an estimation for the net migration movements from Cape Verde was made for the four five-year periods between 1970 and 1990. The results are shown in columns 3-6 of *Table 3.6.*

It turns out that the registered migration data is very good. The difference between the non-migration projected population and the actual population in 1990 is almost equal to the registered total net-migration for the period. The estimations fit to data in four, large age-groups available for the years 1986-1988 in DGE, 1993. The estimated annual average net-migration in four five-year periods from 1970-1990 is compared with the registered migration data in *Table 3.7.* The table shows the difference is larger in more recent years, probably because more recent years would include more temporary migrants who have not bothered to register.

Table 3.6. Estimated age- and sex-specific net-migration in the interval from 1970–1990, with the estimated population in 1990 and the census population in 1990.

Age	Age distribution of migration (% total flow) 1970–1990	Estimated five-year net-migration, net individual migrants 1970–1974	1975–1979	1980–1984	1985–1989	Population with migration estimation 1990	Actual population, census 1990
Women							
0–4	0.00	0	0	0	0	27138	29934
5–9	0.03	335	280	193	257	25413	25448
10–14	0.03	335	280	193	257	21813	21250
15–19	0.27	3015	2518	1739	2315	18271	16971
20–24	0.30	3350	2798	1933	2572	15353	16599
25–29	0.20	2234	1866	1289	1715	15553	13833
30–34	0.03	335	280	193	257	11896	10763
35–39	0.03	335	280	193	257	9009	7871
40–44	0.03	335	280	193	257	4219	4143
45–49	0.02	223	187	129	171	4836	4453
50–54	0.02	223	149	129	171	6250	6361
55–59	0.02	223	187	129	171	6056	5675
60–64	0.02	223	187	129	171	4686	4846
65+	0.00	0	0	0	0	6586	11500
Total	1.00	11166	9292	6442	8571	172483	170137
Men							
0–4	0.00	0	0	0	0	27661	30032
5–9	0.03	586	336	232	327	25863	25652
10–14	0.03	586	336	232	327	22188	21107
15–19	0.25	4886	2798	1933	2728	18261	16587
20–24	0.30	5863	3358	2319	3274	14110	15077
25–29	0.20	3909	2239	2010	2183	14270	12318
30–34	0.03	586	336	232	327	8133	8178
35–39	0.03	586	336	232	327	5444	5076
40–44	0.03	586	336	232	327	2866	2660
45–49	0.02	391	224	155	218	3642	2634
50–54	0.02	391	224	155	218	4196	3935
55–59	0.02	391	224	155	218	3971	4003
60–64	0.02	391	224	155	218	3528	3937
65+	0.00	0	0	0	0	4314	8338
Total	0.98	19152	10971	8042	10692	158447	159534

Table 3.7. Five-year average net-migration, registered, estimated, and ratio. Source for registered migration: DEG, 1993

	1970–1974	1975–1979	1980–1984	1985–1989
Registered	5584	3731	2577	3118
Estimated	6064	4052	2897	3854
Ratio estimated: registered	1.086	1.086	1.124	1.236

Table 3.8. Cape Verdeans abroad at the end of the 1980s in three continents according to two criteria. Source: from Bundeskanzleramt, Austria 1993.

Continent	Persons with at least one Cape Verdean ancestor	Persons partaking in the Cape Verdean culture
North and South America	255000–305000	85000–92000
Europe	92800–102300	50000–65000
Africa	67900–76200	35000–43000
Total	414700–482500	170000–200000

Table 3.9. Estimates of remittances per person sending money using two groups of Cape Verdeans abroad as the sender group.

		Assumption: only revious 20 year sum of emigrants sends remittances			Assumption: all persons partaking in Cape Verdean culture send remittances		
Year	Remittances in million 1990 Escudos	Sum of emigrants	Remittances per emigrant in 1990 Escudos	In US Dollars	Sum of emigrants	Remittances per emigrant in 1990 Escudos	In US Dollars
1973	994	34041	29195	417	134041	7414	106
1974	798	38381	20790	297	138381	5766	82
1975	651	38024	17119	245	138024	4716	67
1976	1905	43945	43354	619	143945	13236	189
1978	2708	52315	51757	739	152315	17777	254
1979	2593	54369	47701	681	154369	16801	240
1980	2795	57099	48958	699	157099	17794	254
1981	4260	60504	70411	1006	160504	26542	379
1982	4284	62182	68901	984	162182	26417	377
1983	3868	64775	59716	853	164775	23475	335
1984	4668	68714	67934	970	168714	27668	395
1984	3161	69471	45498	650	169471	18651	266
1985	3389	67776	50006	714	167776	20201	289
1986	3252	69137	47030	672	169137	19224	275
1987	3364	69589	48336	691	169589	19834	283
1988	3598	74848	48069	687	174848	20577	294

3.3.2 Cape Verdeans abroad

As a result of the high emigration and the tight-knit Cape Verdean communities in the destination countries, the number of Cape Verdeans abroad is estimated to be large. *Table 3.8* shows the number of persons with "at least one Cape Verdean ancestor", and "persons who are participating in the Cape Verdean culture". Both of these definitions by themselves are not very clear: how far back is an ancestor still considered (parent? grand-parent? great-grand-parent?), and what does it mean to participate in the Cape Verdean culture?

These numbers are higher than the actual net number of people who emigrated from 1900-1988, even without mortality of the out-migrants during that period. The out-migrants are estimated to be 453 thousand, and the number who immigrated (most of whom were Cape Verdeans) in the period 1933-1988 is 344 thousand, a net deficit of 110 thousand (rounding errors) persons excluding those who returned between 1900–1932 (sources as *Figure 3.2* above). The fact that the actual number of Cape Verdeans abroad is much larger is because of the natural growth of the emigrants, a natural growth that would be larger than normal if the Cape Verdeans immigrants married non-Cape Verdeans.

The remittances of these migrants are substantial, and particularly in the period 1975–1985 they were large. The upward trend of remittances closely follows the sum of net-migration in the 1970s. Were all the remittances in those years from those who migrated in that decade?

Table 3.9 shows the net remittances per emigrant based on two hypotheses. The first hypothesis is that only those who have emigrated in the past twenty years send remittances.

The second is that remittances are sent by the whole pool of persons partaking in the Cape Verdean culture.

The second column of *Table 3.9* shows the annual remittances sent in the actual year, in millions of 1990 Escudos. The third column shows the sum of net emigration in the last twenty years before the actual year, including that year, and the fourth and fifth columns show the remittances per emigrant in 1990 Escudos and US dollars at the 1990 exchange rate (one dollar to 70 Escudos). A second set of three columns shows the estimation of "persons partaking in the Cape Verdean culture". These are 170 thousand in 1990. It is assumed that the migrants who left their country after 1970 are all in this group. These were 70 thousand. Then, ignoring mortality, there were 100 thousand persons partaking in the Cape Verde culture in 1970. The first column of the second set shows the growing sum of these persons as the migrants from 1970-1990 are added in. The second and third columns of this set show the remittances per person in this group in 1990 Escudos and US dollars.

The table shows that if only migrants from the past twenty years before the actual year are included, then remittances per emigrant ranged from a low of 245 US dollars per year in 1975, one year after independence, to 1006 dollars in 1980. These estimates can be taken to be a maximum of remittances per emigrant. If all persons partaking in the Cape Verdean culture are considered, then remittances per person vary from 67 US dollars per year to 379 dollars per year. This can be considered a minimum of average remittances per emigrant. The actual remittances per person sending may be somewhere in between. The pattern of the values shows however, that remittances per person sending vary from year to year, more precisely, they show that in the crisis years of the 1970s and 1980s, the per emigrant transfers increased, and in the second half of the 1980s, when the economy stabilized, they decreased. *This shows that Cape Verdeans abroad react in a way which is sensitive to economic up- and down-swings in the mother country.*

3.4 Fertility

Cape Verde in 1994 is a high fertility country with a TFR level around five children per women. Although the level is declining, one asks why it is still so high because Cape Verde offers the environment that in other countries and states is or was conducive to decreases in fertility to replacement levels, namely a high level of basic education among child-bearing women; a universal health system well distributed throughout the country; a high density of family planning centers; a relatively high rate of urbanization and an obviously limited natural geographical size. This section analyses the course of fertility changes over the past 30 years. It evaluates the data on fertility given by international and national sources and concludes that the values of fertility given by these data for the 1960s and 1970s are too high, and that they are presently too low. It discusses contraceptive use and fertility among different groups of women, and finds a large fertility difference between women with secondary education or more versus women with primary education or less. The differential contraceptive use in urban versus rural areas is partially explained by educational differences.

3.4.1 Estimating total fertility rates from 1960–1990

Different data sources provide different estimations of fertility levels. *Table 3.10* and *Figure 3.3* show estimates of fertility in 1960, 1970, 1980, and 1990 according to the United Nations, the World Bank, the UNDP, and national Cape Verdean data.

The three data sources with figures for 1960 agree that the total fertility rate, TFR, was around 7 children per woman. In 1970, fertility estimates continue to put fertility at around 7 children per woman, and the national sources indicate an increase. 1970 was the second year of the period of drought that lasted until 1986 (except 1980). It was also the beginning of the very large flow of emigration that characterized the decade. It was nine years into the thirteen year

Table 3.10. Estimates of total fertility rates in Cape Verde from different sources.

Year	UN[a]	World Bank	UNDP	National data
1960	7.0	–	6.9	6.9
1970	7.0	7.0	–	7.5
1980	6.3	6.5	–	6.2
1990	4.8	5.4	4.4	4.3

[a] Numbers for the five-year intervals beginning with the designated year.

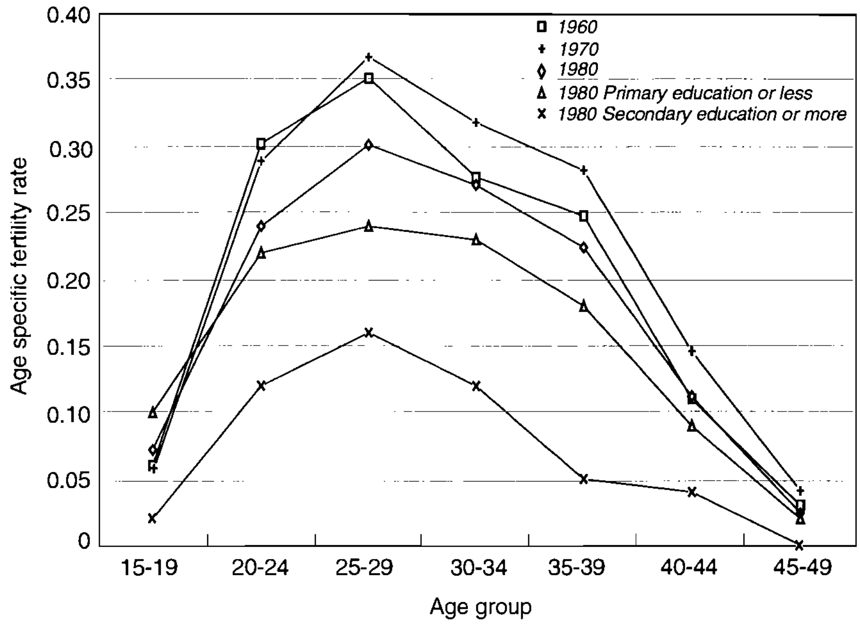

Figure 3.3. Age-specific fertility rates estimated by national sources in Cape Verde in 1960, 1970, 1980, and 1990.

violent struggle with the Portuguese for independence. It therefore seems an unlikely period for the fertility increase indicated by the national data.

In 1980 the sources agree that fertility had declined to slightly over six children. A larger fertility decline is indicated for the decade from 1980–1990 to around 5 children per woman.

The United Nations Population Division and the UNDP estimate low fertility of 4.8 and 4.4 children per woman respectively in 1990. The national data, based on the census of 1990, indicate that fertility was 4.3.

These different data sources indicate a one-third fertility decline in the period from 1960-1990, much of it in the last decade.

An effort to verify these data however, indicated that:

1. fertility was lower in 1970-1985 than the data indicate;
2. fertility was higher in 1990 than the census indicates;
3. therefore, the fertility decline from 1970-1990 was considerably less than indicated by official sources, namely, 16 percent rather than 31–43 percent.

To verify the data from 1970–1985, the cohort component estimation method used for migration is applied in an adapted form, as described in Appendix C. In simple terms, population age-vectors for historical periods are estimated based on the age-structure from a census at the beginning of the interval; data for mortality and the absolute number of births – both assumed correct; and the estimation for migration from the previous section. Using the thus estimated population age-vectors; the absolute number of births; and national data to approximate the shape of the fertility curve (not: the level!), the age-specific and total fertility rates are calcu-

Table 3.11. Total fertility rates used in the historical population simulation compared to the fertility rates estimated by the UN.

Estimate	1970–1974	1975–1979	1980–1984	1985–1989
Estimated TFR	6.15	5.85	5.44	5.15
United Nations data for TFR	7.00	6.70	6.29	4.83

lated. According to this estimation, fertility was 6.17 in 1970–1974; 5.85 in 1975–1979; and 5.44 in 1980–1984.

The fertility estimation for 1985-1990 is approximated by fertility calculated for 1990. The 1990 level of fertility is based on census information. In the census, there were two questions relevant to fertility of the year previous to the census: number of births in the last 12 months; and the number of infants under 1 year of age. Barring large migration flows of infants, these numbers should be similar, and the number of births higher than the surviving number of infants. In the 1990 census of Cape Verde, neither is the case. There are 10295 births counted in the past 12 months, and there are 12322 infants under 1 year.

It is assumed that the number of infants under one year of age is more correct because it follows from the simpler question. The more complex question about births, it is assumed, was answered incorrectly more frequently (births forgotten, misunderstanding the question, absence of the woman concerned from the home at the moment the census-taker was asking the question). With this assumption, the total fertility rate which is indicated by the "number of births in the last 12 months" is adjusted upwards and the resulting total fertility rate is 5.1 for the 12 months previous to the 1990 census.

If the assumptions in this calculation are correct, this would indicate that the fertility decline on Cape Verde in the period 1970–1990 was lower than the data indicate. Table 3.11 compares the official UN estimate of TFR and the model estimate.

3.4.2 Factors affecting fertility: Migration and fertility control

Fertility levels can be affected by factors which are involuntary, such as malnutrition, disease or absence of partners. It can also be affected by voluntary control. On Cape Verde, both factors appear to have had some influence. Involuntary control is found in a correlation of the number of births and periods of migration. Voluntary control is found using a model developed by Coale and Trussel (1974) and adapted by Lutz (1989).

Migration

Figure 3.4 shows the annual number of births recorded by national data from 1960–1992. The number of births recorded by national data follows a rather irregular pattern. Although fluctuations in the number of births can be expected and are usual, more so in small populations like that of Cape Verde, the extent of the fluctuations is large. In 1975 for example, 10196 births were registered. In 1976 there were 14 percent more, and in the following year it was about 5 percent less again.

Following an observation raised by Cape Verde's *Secretaria de Estado da Cooperacao e Planeamento* (1984:18-9) a correlation is made of births and emigration. The *Secretaria* observed that in the year following a period of large emigration, births fell, and after immigration, births increased. *Figure 3.3* shows the annual number of births and the national figures on net migration, shifted forward by one year. The correlation of high emigration and low births is particularly apparent in the 1970s. In that decade, the years after net migration is low (emigration is high), births are also low. Migration is usually individual labor migration, so one can imagine the story that one partner in a relationship emigrates to work, and in the following period, until the migrant returns, or until a new relationship is started, there are fewer babies made. Low

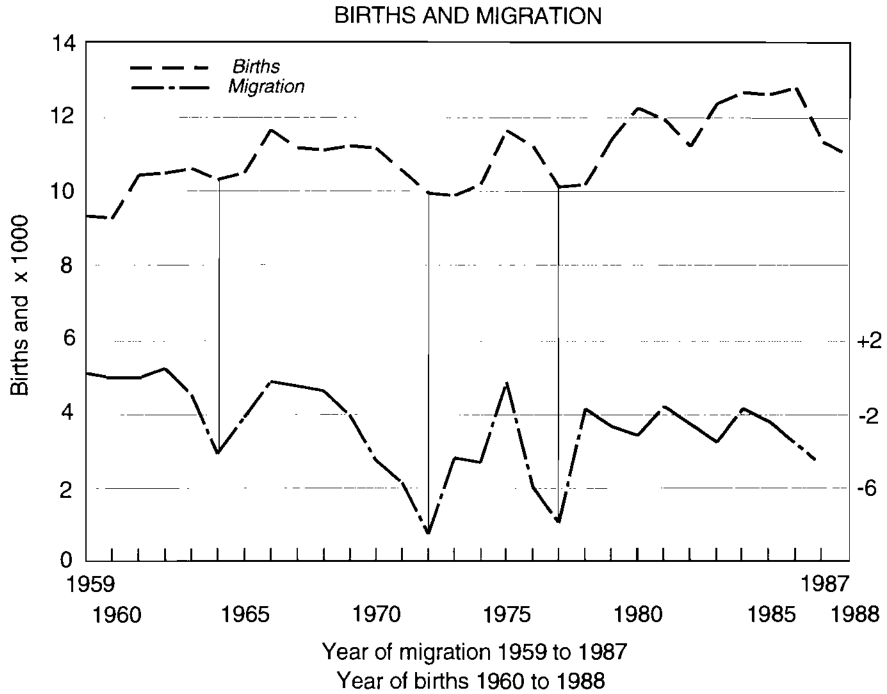

Figure 3.4. Number of births in the period 1960–1988 and the net migration shifted forward one year. Sources: Carreira 1982, 1985, national statistical publications.

net migration indicates that many migrants returned and just after this time, like after a war, more babies are made.

Family Limitation

The level of fertility can also be the result of voluntary decisions to extend or limit family size. Voluntary control of fertility occurs when, according to Louis Henry (1961) "behavior affecting fertility ... is modified as parity increases" (cited in Coale and Trussel, 1974).

How much of the fertility decline since 1970 was controlled in this sense? Coale and Trussel developed a method to measure conscious family size limitation which they described in the article quoted above. The method was later adapted by Lutz (1987). The adapted form is used in the analysis here, and Appendix D discusses the methodology.

The analysis of fertility control shows that women with secondary education in 1990 limit their family size to almost replacement level, and that this is controlled fertility, while women with primary and less education in 1990, as well as all women in 1960, 1970, and 1980 did not control their fertility by number of children, although total fertility declined.

It is possible that high levels of separation or single adults lead to the lower fertility levels among women with primary education. In the section above, emigration was identified as one possible intermediate factor affecting fertility. There is also a high percentage of women who are raising children without a male partner – this is reflected in a large percentage of women who are heading households with children in the 1990 census. If this percentage of single women has been increasing, it may account for a non-controlled fertility decline.

The fertility control among women with secondary and higher education is correlated with the higher percentage of contraceptive users in the urban areas. The percentage of women who have secondary education is higher in urban areas. This is discussed in the next chapter in the sections on health care and women's status.

3.5 Conclusions

This chapter analyzed mortality, emigration, and fertility on Cape Verde. The mortality analysis estimated that life expectancy was 32 years in the period 1900–1948. Without the famines which occurred in that period, life expectancy would have been six years higher. In 1950, life expectancy was estimated by the UN to be 50 years. In the period 1950–1990, life expectancy increased by 17 years. The analysis in this chapter suggests that five years of that increase are due to lowered infant mortality and four years are due to fewer deaths caused by diarrhea in non-infants.

The chapter makes an estimate of emigration from 1970–1990, using a model of historical population projection. The calculation shows that the proportion of women in emigration increased in the period from 1970–1990 from 37 percent to 42 percent; that most emigrants were young adults; and that the emigration data and the estimation are very similar. Emigrants have been an important source of remittances in all of Cape Verde history. In one experiment, the sum of net-emigrants in the twenty years before the actual year are taken as the pool of remittance senders, and compared to the total remittances which were sent to Cape Verde in the period 1973–1988. This experiment led to an estimation of annual remittances varying from 294 1990 US dollars to 1006 per person sending and showed that remittances sent per person are sensitive to the economic situation in Cape Verde.

Fertility is analyzed by using the same method of historical population projection as the migration estimation. According to these calculations, fertility was 12–14 percent lower in the period 1970–1984 than is recorded by international and national sources and was 7 percent higher in the period 1985–1989. This implies an even slower fertility decline than estimated by the official data, from 6.15 in 1970 to 5.15 in 1990. Some part of this decline may be due to involuntary factors such as absence of partners, a correlation of fertility and emigration shows. An analysis of fertility control showed that in 1990 only women with secondary education or higher were controlling their fertility.

Chapter 4

Social Factors

4.1 Introduction

This chapter discusses some of the social factors on Cape Verde: education; labor force participation particularly in connection with women's' status; urbanization in connection with the decreasing proportion of the population depending on agriculture; and public social programs such as direct aid to the poor, the health care system, and the pension system.

Education, it was found in the last chapter, is related to the level of fertility, and was driven in the past partly by the desire to emigrate. Education in this century has increased from almost nil to a literacy rate of 75 percent. The school system has three levels: basic, intermediate, and secondary. There is no university on Cape Verde and about 5.4 percent of the age-group 20–24 was studying abroad in 1992. As education increases, the transition rates out of school change shape, namely that the peak of leaving school is transferred to older ages.

The labor force participation rate of men and women on Cape Verde in 1990 was high compared to, e.g., Mauritius. The labor force participation rate of men was almost universal in the age category 15–64 and even in the age-group 70–74 was over 50 percent. The labor force participation rate of women was 45 percent, one and a half times as high as in Mauritius in 1990 where present economic success is backed by female labor in textile factories.

The labor force participation rate of women is high despite high fertility levels. It correlates to a social situation where 38 percent of the heads of households are women, and 39 percent of the women in the age group 15–49 are raising children without being in union (calculated from DGP, 1991:93). Women are working in: agriculture, services, commerce and construction in descending order of frequency. Construction is not a "traditional" sector for female labor and the large representation of women in that sector is due to their employment by the Government in the public infrastructure building program, which is part of the poverty-alleviation programs. Thirty percent of the women in the labor force is self-employed, and most of them run small-scale agricultural and service enterprises.

The employment of men and women in agriculture has declined as a relative portion of total labor activity, while it has remained constant in absolute terms. Since 1970, the absolute number of people "dependent on agriculture" has remained constant (US Dept. of Agriculture, 1993); during the 1970s drought, it even declined slightly. All of the population increase since 1970 has been absorbed by activity in non-agriculture and dependence on non-agricultural activities. Later sections of the study discuss whether this stagnation is economically, socially, or environmentally determined, or by all three.

The higher employment and dependence level in non-agriculture activities is matched by the absorption of 54 percent of the population growth in urban areas, although only 20 percent of the population was urban in 1970 (UN, 1993). An estimate is made in this chapter of the rural-urban migration rates that have contributed to high urban population growth and slow rural population growth.

This chapter also discusses the public social programs, which include direct aid to the poor; a social security scheme; and a public health system including maternity health/family planning centers.

Table 4.1. Education level by sex and age at the 1990 census on Cape Verde (in %). Source: DGE, 1992.

Age group	Women Illiterate	Women Primary education	Women Secondary education	Men Illiterate	Men Primary education	Men Secondary education
15–19	0.20	0.44	0.35	0.19	0.47	0.34
20–24	0.32	0.50	0.18	0.24	0.53	0.23
25–29	0.47	0.39	0.15	0.28	0.48	0.25
30–34	0.64	0.18	0.17	0.37	0.34	0.29
35–39	0.73	0.14	0.13	0.39	0.29	0.32
40–44	0.76	0.12	0.12	0.41	0.30	0.29
45–49	0.83	0.10	0.07	0.54	0.25	0.21
50–54	0.89	0.08	0.03	0.65	0.25	0.10
55–59	0.92	0.07	0.01	0.72	0.23	0.05
60–64	0.92	0.07	0.01	0.74	0.23	0.03
65–69	0.92	0.07	0.01	0.72	0.25	0.03
70–74	0.93	0.06	0.01	0.75	0.21	0.03
75+	0.94	0.06	0.00	0.82	0.18	0.00

4.2 Education 1900–1990

Education has increased greatly in Cape Verde in this century. This is shown by the level of education achieved by different age-groups in the 1990 census. *Table 4.1* shows the level of education achieved by the five-year cohorts counted in the 1990 census.

The illiteracy among the cohorts who were 75 plus in 1990 and who would have started school at age 6 before 1921 is 94 percent among women and 82 percent among men.

An increase in education followed the passing of the 1917 United States immigration law which permitted only literate migrants into the country. As Cape Verde was so dependent on this migration flow, the law started a drive among men to obtain at least the ability to read and write. The cohorts who started school between 1921–1941 have a higher literacy rate among the men. The literacy rates for men are 25 percent. The purposefulness of this education drive is reflected in the fact that the illiteracy rates of women are virtually the same in this cohort as in the earlier cohort and the rates of secondary education – which was beyond the United States immigration requirements – remain very low for men and women. The proportion with secondary education in these cohorts is just over three percent for men.

Education expanded further around 1940. This was due to an increasing awareness by the Cape Verdeans of the value of education, more than a Portuguese intervention (following De Sousa Reis, 1989). The cohorts who were 6 years old between 1941–1950 received more education that the preceding cohorts: the proportion of people went to school was 33 percent, and of the people entering school, the proportion continuing to secondary was higher – 4 percent had secondary education. There were also more women who went to school in these cohorts. The expansion of education continued for the cohorts who were 6 years old between 1951–1960. Of these cohorts, 51 percent went to school, and 10 percent went to secondary school.

Another increase in education followed independence in 1975. The new government gave high priority to achieving higher rates of literacy and initially concentrated on basic education. This effort was soon followed by an expansion of secondary education as well. Of the children who were age 6 between 1966–1970, 20 percent had no education in 1990. Of those who were 6 between 1971–1975, 13 percent had no education, and those who were 6 between 1976–1980, only 8 percent had no education.

The drive for secondary education soon followed. The proportion of people with secondary education is 10 percent for the group who were 6 between 1966–1970, the same as cohorts born twenty years earlier. It was 12 percent among the group who were 6 between 1971–1975, and 20 percent among the group who were 6 between 1976–1980, who were 15–19 in 1990. Another

Table 4.2. Total population, percentage in school and percentage in secondary school among boys and girls born 1973–1978 in urban and rural areas at the 1990 census. Source: DEG, 1993.

Group	Urban, born 1973–1978		Rural, born 1973–1978	
	Boys	Girls	Boys	Girls
Total population	10648	11093	12553	12287
In school	7498 (.70)	7743 (.70)	5966 (.48)	5542 (.45)
In secondary school	2046 (.19)	2343 (.21)	715 (.06)	577 (.05)
Ratio: in secondary school/ in school	.27	.30	.12	.10

important feature is that the education level of young women is practically equal to that of men in the same age-groups.

As a result of these efforts the rate of illiteracy dropped from 60 percent in 1975 to 25 percent in 1990.

4.2.1 Present school system

The present school system on Cape Verde consists of three levels. The first four years are *ensigno basico elementar*, followed by two years of *ensigno basico complementar*. Almost 100 percent of the children in the relevant school age today begin the *ensigno basico*. Duplication rates are very high, about 20 percent, and of the number of children who begin school, only 80 percent successfully complete the elementar, of those who continue 67 percent complete complementar (Ministerio de Educacao e Desporto – MED, 1992). The third level is the *curso geral*, which may be secondary education either at a lyceum or in a technical school. According to the MED, only 50 percent of those who finish the complementar continue to a *curso geral*. These numbers correspond to the proportions in school by one-year age groups counted in the 1990 census.

In many schools, the resources are scarce, particularly class-rooms. The average number of pupils per classroom in elementary education is about 60 and so the school system functions in rotation. Furthermore, qualified teachers are lacking. In 1992/3 only 25 percent of the teachers in *ensigno basico elementar* was qualified, up from 20 percent in 1989/90 and 14 percent in the *ensigno basico complementar*, down from 19 percent in 1989/90. This may be part of the reason for the high rate of duplication. The situation in secondary education is better: here 54 percent of the teachers was qualified in 1992/3.

The 1990 census data show one effect of the high duplication rates. This is that although the school participation rates are high until the mid-teens, there is a large group of children who remain in primary beyond the "normal" age for primary school, and a significantly smaller percentage of the children – 30 percent in urban areas, and 7 percent in rural – continues to secondary school

Table 4.2 shows the percentage of children born between 1973–1978 in total and in school who were 12 1/2 – 18 1/2 years old at the 1990 census and the percentage who were in secondary school for boys and girls in rural and urban areas separately. In the urban areas 70 percent of the boys and girls in this age-group both were in school, but only 20 percent of the boys and 23 percent of the girls was in secondary school. In the rural areas, 48 percent of the boys and 45 percent of the girls was in school, while 6 and 5 percent of the boys and girls respectively were in secondary. These data reflect the high redundancy rates, and the late-school starting rates. They also indicate that these factors are stronger in the rural areas than the urban areas, but almost equal between boys and girls.

There is no institute of tertiary education on Cape Verde – students study abroad. Before going abroad, students who have finished the lyceum spend one year in the capitol, Praia, in a university preparatory course in order to receive a stipend from the Cape Verde government.

Table 4.3. Evolution of costs of education from 1983–1987 in 1990 and current Escudos, by school level. Source: calculated from DEG, 1989:174–7.

	Costs per student, 1000 1990 Escudos		Number of students		Total costs, million current Escudos		
Year	Primary	Secondary	Primary	Secondary	Primary	Secondary	Total
1983	5566	12943	55195	4365	163	30	268
1984	6189	15396	56686	4644	204	41	340
1985	5933	14900	58084	5440	209	47	356
1986	5098	13394	60227	5580	218	53	376
1987	5849	16136	62727	6272	268	74	475
1990							672

The students go abroad to many countries. The largest groups are in: Portugal 40 percent; Cuba 23 percent; Brazil 18 percent; non-Portuguese European countries 7 percent. The number of stipends in the past four years was: 230 in 1990/1; 160 in 1991/2; 200 in 1992/3; and 232 in 1993/4. In 1990/1 37 percent of the stipends were for women (MED, unpublished statistics). The largest group of students is in economics, followed by engineering and science. The students presently abroad with a stipend is about 5.4 percent of the age-group 20–24 resident in Cape Verde. These 5.4 percent may be an under-estimate of actual persons studying because the government statistics do not include people who have gone abroad to study on their own means.

Education makes up 15 percent of the total public expenditure and 3 percent of GNP. This puts Cape Verde in the middle range of African countries.

Table 4.3 shows the evolution of the costs of education in Cape Verde from 1983–1987 (source: DEG, 1989) in 1990 and current Escudos. The table shows that the expenditures per pupil and level remained fairly constant at the primary level in the period 1983–1987 and increased by an average of 5.5 percent annually per pupil at the secondary level. This means that a large part of the increasing government education expenditures were due to a growing number of students in primary and secondary school, particularly in the more expensive secondary level.

4.2.2 Education transition rates

One of the characteristics of more education is that the transitions out of school occur at progressively later ages. School exit transition rates are similar to fertility or mortality rates: they result in "births" in the non-school population, or conversely, "deaths" in the school population.

Like fertility rates or mortality rates, school exit transitions have characteristic age-patterns. In a population where most children leave the "school-age" population without ever having gone to school, the transitions into the "non-school population" are high in the age-group 5–9. In a population which enforces mandatory school attendance until age 15 or higher, the school exit transition rates are low in the age-groups below 15 and high in the age-groups that follow.

An estimate is made of the school exit transition rates on Cape Verde in 1990 based on the 1990 census.

The transitions are calculated as if they were standardized mortality rates: the proportion of the population that left school between age x and $x-1$, divided by the proportion of people that was still in school at age $x-1$:

$$Tr\left(\frac{S_{x-1,n-1}}{NS_{x,n}}\right) = \frac{NS_{x,n} - NS_{x-1,n-1}}{S_{x,n}} \tag{4.1}$$

where $S_{x,n}$ is the proportion still in school in period n and age-group x, and NS is the proportion not in school. By dividing the proportion into the population with secondary or primary education, transitions to the non-school population with primary education or secondary education are found. These transitions are artificial, because they mix the transition experience of different periods: for example, the 20–24 year old with primary education who is included in the

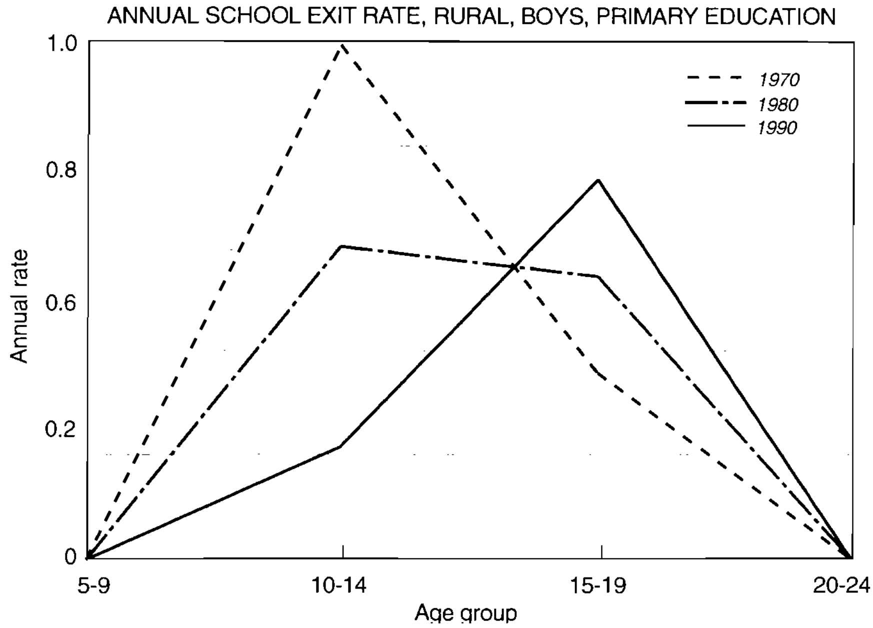

Figure 4.1. School exit transition with primary education for rural boys in 1970, 1980 and 1990.

non-school population at time n left school between 10 and 15 years before. To minimize the error, only the transition rates for the ages 10–14, 15–19 and 20–24 are calculated, after which everybody is assumed to have left school.

These estimates are checked with an historical projection of a population with multiple education status groups, or states. The methodology for this type of projection are described in Chapter 8 on the PDE-model.

Figure 4.1 shows the estimated school-exit transition rates for primary education for rural boys in 1970, 1980, and 1990. In 1970, the peak of "school exit" rates was in the age-group 5–9, which meant that the majority of rural boys in this period received no or very little education. In 1990, this peak had disappeared and larger proportion of rural boys was leaving school at a higher age with more years of schooling.

4.3 Labor Force Participation, Employment, and Women

Labor force participation and employment rates are important social indicators. They provide information about how work is distributed in a population. They are also important economic indicators, particularly their difference from each other. When the two rates are far apart - i.e., employment is far below labor force participation - this means a high unemployment rate.

Figure 4.2 shows the labor force participation and the employment rate among men and women in 1990, as well as the labor force participation rate in 1980.

The labor force participation rates were high among men from age 20–64, and are only just below 50 percent in the age-category 75 plus. The labor force participation rates among women in 1990 were almost double the 1980 level. The pattern of female labor force participation is one in which the highest labor force participation rates are among women in the age-group 20–24 and consecutively less at older ages.

The unemployment is estimated by taking those members of the labor force who have "no profession". These are concentrated in the younger age-groups, where unemployment is most common. The employment rates are found by subtracting the estimated unemployment from labor force participation. The result is an unemployment rate of 51 percent for men and women in the age-group 15–19 and decreases for older ages.

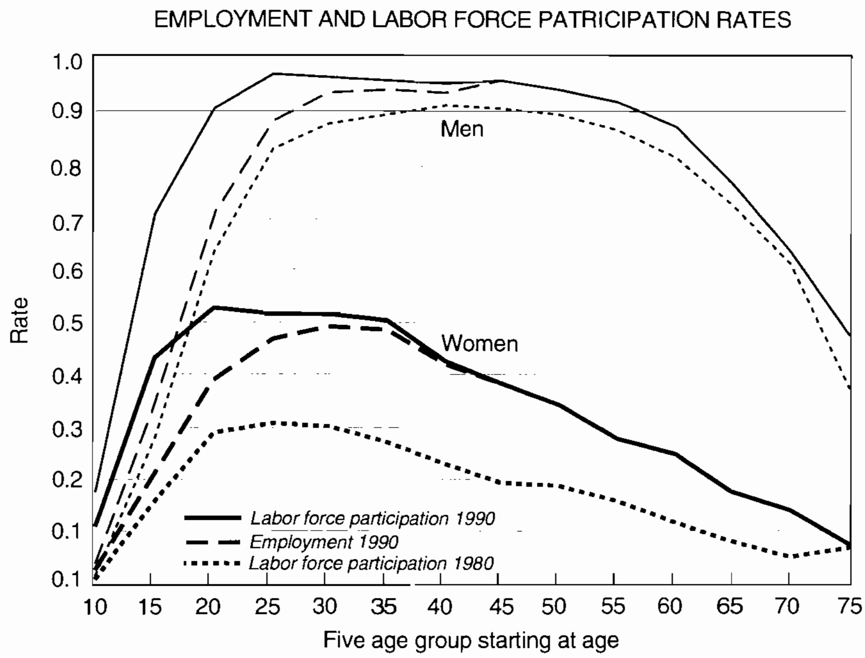

Figure 4.2. Labor force participation rates and employment rates for men and women in 1980 and 1990.

Table 4.4. Employment of men and women in 1990, value added in 1988 (millions of 1990 Escudos), and value added per worker (thousands of 1990 Escudos). Sources: ILO, 1993, census 1990, input–output table 1988.

	Self-employed workers		Employed workers		Percent	Value added in millions of	Valude added/ worker in
Sector	Men	Women	Men	Women	women	1990 Escudos	1000 1990 Escudos
Agriculture	10575	6187	7101	3870	.36	3476	125
Mining	121	180	61	16	.52	165	436
Manufacturing	1477	849	2515	593	.27	1457	268
Electricity, gas, water	36	1	693	150	.17	258	293
Construction	524	14	17840	4299	.19	2776	122
Commerce	2049	6057	2898	1597	.61	6481	514
Transport and communication	720	14	4626	744	.12	3232	529
Finance	40	12	432	337	.43	2226	2711
Social and personal services	596	196	7653	8849	.52	2764	160

The employment rates are higher than the labor force participation rates in 1980. This indicates that there is not only a greater desire to work in 1990 than in 1980, which would be indicated by the higher labor force participation rates, but actually greater employment. The employment increase was largest among women in commerce.

4.3.1 Employment by economic sector

Table 4.4 shows the employment of men and women in major economic categories dividing self-employed and employees. The largest employment sector is agriculture, followed by construction and social and personal services. Women are most represented in the sectors agriculture, construction, commerce, services, and finance.

The table shows the 1988 value added in millions of 1990 Escudos and the value added per employed person. The lowest values added per worker are in the sectors agriculture, construction and services all of which employ large numbers of women. The value added per worker in commerce (which includes hotels and restaurants) which employees many women is relatively high.

The weighted average income for men and women according to this table, is 230 thousand Escudos per male worker, and 266 Escudos per female worker. The high female average is because there is a relatively large group of women in the commerce sector which is a sector with a high average income. This calculation does not take into account a differential distribution of men and women within each sector. A closer analysis shows that in agriculture, construction and commerce, women are concentrated in the low income branches of these sectors. How much this influences the income distribution is not known, although the direction would be to increase average male income and decrease female income.

The women working in agriculture are more represented in rain-fed agriculture. 41 percent of the rain-fed family farms were headed by women, and only 20 percent of the irrigated farms (MRDF, 1991:53). This is the branch of agriculture that is subject to greater risk of crop failure due to unfavorable weather.

Statistics on the women in commerce, of whom 79 percent are self-employed, do not show how much their average income is. However, sociological studies (e.g., Stockinger, 1993) shows that these women are, to a very large extent, so-called *rabidantes*, market women, whose enterprise size ranges from, e.g., a portable candy-box or box of mangoes, to full-scale, permanent market stalls.

The large group of women who are working in construction is employed in the public sphere. This program is the *Frentes Alto Intensidade Mao de Obra* (FAIMO), which means fronts of high intensity hand-labor. This program was started to aid poor farmers in the frequent bad crop years. The program is financed by the proceeds from selling international food aid. This type of "food for work" program in Cape Verde and other places, is discussed in Sen and Drèze (1989).

According to the agricultural census, 4550 women were employed in the FAIMO in 1988 (MRDF, 1991:80), equal to the number of women working in construction in 1990. If all women in construction are working in this program, they are working in the branch of construction which is less remunerative than working in the private sphere.

The system works as follows: The international food aid is sold to the people. The proceeds are used to employ the people. The workers in the FAIMO program construct roads, landing strips, dikes, plant trees, all of which falls in the construction sector. The work is extremely labor intensive, which saves on the expensive capital equipment which is scarce in Cape Verde. FAIMO employed 18–25 thousand in the period 1976–1986 (Krüger, 1988) which was 20–27 percent of the 1980 labor force. Since then, it has decreased in absolute and relative size. According to the Agricultural Census 1988 (MRDF, 1991), 12 thousand were employed in the FAIMO in 1988. The 1990 Population Census counted 13 thousand working in public construction.

The pay is minimal as the idea is only to relieve farmers in periods of drought. However, it is apparent that even after periods of drought (e.g., in the agricultural boom years 1986/7 and 1987/8) the FAIMO workers have not returned to the farms to be agricultural workers.

It is guessed by, e.g., Krüger (1988), and oral sources, that this is because the work for FAIMO is more secure than risky farming, particularly in the very marginal areas. This author's hypothesis is that non-agricultural employment on Cape Verde is a necessity due to the limited agricultural possibilities on the one hand and a growing population on the other. Section 4.4 discusses this topic in relation to urbanization. As women are working in that part of agriculture which is judged to have the least possibilities of expansion (e.g., rain-fed agriculture, USAID, 1976), they are particularly dependent on the FAIMO.

Table 4.5. Adults and children living in households by size and sex of household head.

	Households headed by women		Households headed by men	
Household size	Average persons under 15	Average persons over 15	Average persons under 15	Average persons over 15
0	2.1	2.3	2.4	2.9
1	0.0	1.0	0.0	1.0
2	0.6	1.4	0.1	1.9
3	1.2	1.8	0.7	2.3
4	1.9	2.1	1.5	2.5
5	2.5	2.5	2.2	2.8
6	3.1	2.9	2.9	3.1
7	3.6	3.4	3.5	3.5
8	4.1	3.9	4.1	3.9
9	4.6	4.4	4.5	4.5
10+	5.9	4.1	5.6	4.4

4.3.2 Women's status and the need to work

One explanation for the high labor force participation rate of women is that there is a large group of women who are independent of men, or, who do not have a man to support them and their children.

According to the 1990 census, there were 67,619 households of which 25,879 were headed by women. Data in the Fertility Survey 1988 (General Directorate of Planning, GDP, 1991) shows that 39 percent of the women interviewed with children were *not* living in union with a man. This survey further showed that 60 percent of the women who were single were working or looking for work, compared to 36 percent among the women in consensus union or married.

The sex and dependence structure of households by sex of head and number of children further indicate the independence of women from men. *Table 4.5* shows that the female-headed households in 1990 contained an average of 2.1 children under 15 years, and 2.3 adults over 15. Households headed by men contained an average of 2.4 children under 15 and 2.8 adults. By itself, this indicates a weak tendency that those households headed by women contain fewer adults in working age – i.e., fewer men. Correcting for household size the pattern of more children to fewer adults in households headed by women shows up more strongly. *Table 4.5* shows that at every household size those headed by women have significantly more children and fewer adults supporting them. For example, at household size two those headed by men contained almost no children (an average of 0.1) whereas those headed by women contained an average of 0.6 children. At household size three, households headed by men have 2.2 adults and .7 children on average (rounding errors) while those headed by women have 1.7 adults and 1.2 children.

To some extent, women who are living without a male partner in Cape Verde are supported by remittances from a man abroad. The Agricultural census (1988) found that 42 percent of the agricultural establishments headed by women received remittances from abroad, compared to only 23 percent of those headed by men. The average dependence on remittances in the whole population by sex was not clear from the available information.

4.4 Dependence on Agriculture and Urbanization

The decline in the proportion of the population dependent on agriculture, according to the data, is parallel to the decline in the proportion of the population which lives in rural areas. *Figure 4.3* shows the number of people in Cape Verde who were "dependent on agriculture" according to the United States Department of Agriculture (1994), the number of people living in rural areas according to the United Nations (1993), and the total population according to the same source.

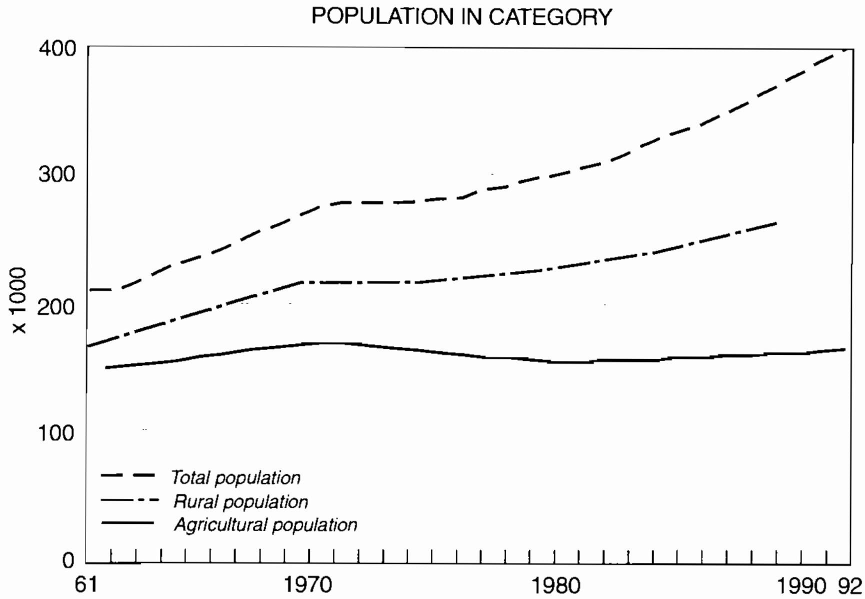

Figure 4.3. Total population and agricultural population 1961–1992 according to the United States Department of Agriculture (1993), and the rural population 1960–1990 according to the United Nations, 1993.

The absolute number of people dependent on agriculture is almost no larger in 1992 than it was in 1962. During the drought of the 1970s there was a decline in the number of people dependent on agriculture.

The rural population growth has been outpacing the agricultural stagnation slightly. Average annual population growth from 1960–1990 in the rural population was 1 percent lower than the total population, but higher than the agricultural population. During the 1970s, rural population size stagnated parallel to the decline in the population dependent on agriculture. In 1960, 31 thousand people were living in rural areas and not dependent on agriculture; in 1970 there were 44 thousand; in 1980 during the drought this figure almost doubled to 77 thousand; and in 1990 there were 106. A large part of the rural population which is not dependent on agriculture is dependent on the FAIMO, which is meant as a relief program for poor farmers.

The stagnation in the agricultural population and the slow growth of the rural population contrasts to the average annual total population growth rate of almost 3 percent annually from 1960–1990. The difference is made up by the fast growth of the urban population.

4.4.1 Rural-urban migration

The urban areas in Cape Verde have grown relative to the rural areas because of rural-urban migration, which has probably been considerable in the past three decades. The data do not show urban-rural migration, but it can be estimated using natural growth rates and international migration rates. The rural-urban migration rate is estimated by taking the difference between the actual rural population growth rates and the natural growth rates minus net migration.

$$Ti = r - (nr - nm) \qquad (4.2)$$

where Ti is the internal transition from rural to urban areas; r is the actual growth rate of rural areas; nr the natural growth rate; and nm the net-international migration rate.

The natural growth rates on Cape Verde since 1970 averaged: 2.7 percent annually from 1970–1975; 2.5 annually from 1975–1980; and 2.9 during all of the 1980s. It is assumed that the natural growth rates were similar in urban and rural areas. In 1985, the fertility rates in urban areas were only slightly lower than in rural areas. International migration must be subtracted

Table 4.6. Estimated rural-urban transition using United Nations data.

	1970	1975	1980	1985	1990
Natural growth %	2.5	2.7	2.9	2.9	
Total population × 1000	267	279	289	324	363
Rural population × 1000	215	219	221	240	259
Rural growth %	0.4	0.2	1.6	1.5	
Rural-urban migration %	2.3	2.3	1.3	1.4	

from natural growth. Section 2.4 contains information on total net-international migration, but this data is not separated between urban and rural migrants. This problem is solved in the following way: All migrants must go from a rural to an urban area before leaving the country, therefore, all international migration is from urban areas. The rural-urban migration rate then includes those who are only going to make a stop-over in town to board the airplane or the boat. This inflates the urban population (to the slow growth of the rural population it makes no difference if the migrants leave to the city or abroad). But, since all emigrants leave from the urban area, this urban inflation is compensated. It is at least true that people who had lived abroad five years before the 1990 census were virtually all located in urban areas.

Using this method on the United Nations data, annual rural-urban migration rates are estimated. The results are shown in *Table 4.6.* The rural-urban migration rate found using the United Nations data is 2.3 percent annually during the 1970s and 1.4 percent annually during the 1980s.

In the future, it is likely that rural-urban migration will continue, but it is not sure to what extent. However, the smaller the relative size of the rural populations, the less urban growth will be affected by rural-urban migration.

4.5 Social Programs: Direct Poverty Aid, Pension Schemes and Health

4.5.1 Direct poverty aid

The largest poverty alleviation program, in terms of the number of people it affects, is the FAIMO program which involves employing those who have no employment and income. Cape Verde also has programs of direct poverty aid for those who have no income and are not able to work.

According to the Director of the Ministry of Social Works, Ms. Fortes, 7,500 handicapped, elderly and disabled persons receive direct food aid. Further, 4028 families in April, 1994, equal to about 25 thousand persons, or 7 percent of the population, received family food aid. These families are mostly single women with children. There are two rations of food: one is a fixed amount for households with up to five members, and the second is a fixed amount about 30 percent higher, for households with six or more members. With this system, a single woman with five children in her household has more food per household member than a single woman with three children in her household.

In total, 9 percent of the population in Cape Verde received direct food aid in 1994. This is less than the total population which is estimated to be ultra poor. According to a World Bank estimate (1994), 22.5 percent of the population in rural areas was ultra poor and 7.4 percent in the urban areas.

4.5.2 Pension scheme

Until recently, 1983, Cape Verde did not have a social security system except for fixed government employees. Since 1983, a large system with 20,000 (of the 91,000 in 1990) employees was set up for all those with fixed posts in companies. The system offers child maintenance (300 Escudos per month per child up to the fourth child), maternity leave, sick leave, and pensions. In 1994, the capital fund of this scheme was 3599 million Escudos (about 15 percent of GDP). So far, there have been few employees actually receiving the benefits.

4.5.3 Public health system

The public health system in Cape Verde is designed to give basic medical care to everybody. There are a large number of centers spread around the country. In 1990, there were 2 central hospitals (Praia and Mindelo); regional hospitals, 15 health centers, 22 health dispensaries, and 60 community health units "offering good access for the majority of the population. Nearly 81 percent of the population are less than an hour walk from a basic service facility" (World Bank, 1994:7). This was achieved at a cost of 367 million Escudos in 1990, which is only 10 percent of government consumption, and 3 percent of GDP. The health expenditures per capita have kept pace with population growth in the past 20 years, although the historical model simulation also showed that per capita expenditure hardly increased.

The health expenditures follow an age pattern which looks like the mortality pattern: a peak in infancy and young childhood, and a second, higher peak in old age. Therefore, an economy which is experiencing for example, aging, can expect to have rapidly increasing health expenditures even if the actual quality of health care does not increase. In the industrialized countries, this effect of age is having macro-economic consequences.

There are two reasons why developing countries can achieve relatively large results from relatively low levels of health care: 1) at a high level of mortality, one first gets rid of the causes of death that are cheapest to handle. These happen to be many infectious and deprivation diseases which are at the same time the diseases which are most common and causing most of the deaths before the epidemiological transition. 2) The age structures of the populations in most developing countries are skewed towards the young and – from the health care point of view – cheap age groups. These two forces help developing countries setting up a basic health care system. When this is combined with political will, and a good spread of health centers, which are giving out the relatively cheap medicines and hygienic advice, then good health results can be expected.

Table 4.7 gives an indication of what the per capita health expenditures per person in each five-year age group in Cape Verde would have been if the health expenditures followed the age-pattern found in Sweden. Using the Swedish data on age-specific health expenditure an estimate is made of the age-specific health expenditure in Cape Verde.[1] Sweden was the only country for which age-specific health expenditure estimates were found. As the pattern of health expenditure is expected to be of a similar shape in all countries – following the mortality curve – this pattern was used, in spite of the great difference between Sweden and Cape Verde. Total health expenditure in 1990 was 367 million Escudos.

The network of basic health centers, and particularly the maternal and infant health care centers – sometimes separate, sometimes together with the basic health centers – provided an existing network on which to build the family planning program. This program was not initiated until 1984, although family planning was an international concern already in the 1970s (e.g., the World Population Conference, 1974). However, in the 1970s population growth on Cape Verde slowed as discussed in Chapter 2, due to emigration and age-structure, and Cape Verde had to an important extent become independent of its national territory and natural resources.

The organization which runs the infant and maternal health centers cum family planning program is called *Program Maternel e Infantil/ Planning Familiale* (PMI/PF). In June 1993, there were 45 PMI/PF centers in Cape Verde. *Table 4.8* shows the number of centers per island, and an approximation of the number of women in the age-group 15–49 per island. The density of the centers per women in childbearing ages is very high. It ranges from 321 women per center on Boavista to 2775 on Fogo, but averages between 1000–1500. This is a higher density than was

[1]The same procedure was used in the PDE-Mauritius study.

Table 4.7. Estimation of per capita health expenditure in Cape Verde in 1990, using the unit health expenditure distribution from the Mauritius PDE-study. Source: Swedish data; DEG, 1993; own calculations.

	Unit pattern of health expenditure		Population 1990		Health units per age group		Expenditure in 1990, in 1990 Escudos	
Age	Women	Men	Women	Men	Women	Men	Per capita	Age group (millions)
0–4	1.3	1.3	29934	30032	39812	39943	817	49
5–9	1.0	1.0	25448	25652	25448	25652	614	31
10–14	1.0	1.0	21250	21107	21250	21107	614	26
15–19	1.3	1.3	16971	16587	22062	22061	807	27
20–24	1.7	1.3	16599	15077	27554	20052	923	29
25–29	1.7	1.3	13833	12318	22963	16383	924	24
30–34	1.7	1.3	10763	8178	17867	10877	932	18
35–39	1.7	1.3	7871	5076	13066	6751	940	12
40–44	2.0	2.0	4143	2660	8286	5320	1228	8
45–49	2.0	2.0	4453	2634	8906	5268	1228	9
50–54	2.3	2.3	6361	3935	14821	9169	1431	15
55–59	2.3	2.3	5675	4003	13223	9327	1431	14
60–64	2.7	2.7	4846	3937	12890	10472	1633	14
65–69	3.7	3.7	2981	2401	10910	8788	2247	12
70–74	5.3	5.0	2623	2063	13981	10315	3184	15
75–79	8.3	7.3	2711	1901	22583	13934	4862	22
80–84	11.7	10.0	1881	1331	21932	13310	6738	22
85+	17.7	13.0	1304	642	23029	8346	9900	19
Total								367

Table 4.8. Health centers with family planning services on Cape Verde, 1993. Source: Annual Report of the PMI/PF, Praia, 1994.

	Health centers	Medical personnel	Women in district 1990[a]	Women per center	Women per personnel
Santo Antao	8	26	10609	1326	408
Sao Vicente	5	19	7740	1548	407
Sao Nicolao	2	3	2921	1460	974
Sal	1	2	1045	1045	523
Boavista	2	2	642	321	321
Maio	1	2	1156	1156	578
Santiago	22	54	35854	1630	664
Fogo	3	8	8324	2775	1041
Brave	1	6	1402	1402	234
Cape Verde	45	122	69693	1267	
Mauritius, 1972	92		176913	1923	

[a]Women in age groups who had lived on the island five years previously. Present residence was not published in the Census 1990 document.

achieved in Mauritius in 1972! These centers are disadvantaged however, because the population of Cape Verde is much more sparsely distributed than on Mauritius. On Cape Verde, the 45 centers make for one center per 73 km^2 whereas on Mauritius the 92 centers were one per 20 km^2. This indicates that, barring a considerably more efficient distribution of family planning centers than health centers, less than 81 percent of the population is within a one-hour walk of the family planning centers.

According to the Director of the PMI/PF almost all women with children come in contact with the centers to vaccinate their children, but they might not come until the baby is a year or so old and they may come very infrequently.

Table 4.9. The number of women using contraception from PMI/PF on Cape Verde 1984–1992. Numbers compiled from annual reports 1984–1993 of the PMI/PF, Praia.

Year	Number of women	Growth rate of use (%)
1984	3908	
1985	2726	–36
1986	4883	58
1987	7773	47
1988	9328	18
1989	13941	40
1990	14931	7
1991	16145	8
1992	17674	9

Since the inception of the family planning program in 1984, the number of women using contraception increased from 4000 in 1984 to almost 18000 in 1992. It was 25 percent of the women in childbearing ages in 1990. *Table 4.9* shows the number of women using contraception from the PMI/PF 1984–1992.

The growth rates of contraceptive use were high at the end of the eighties, but very slow during the nineties. This pattern could mean the initial upswing of contraceptive use was due to the satisfaction of an existing desire among a limited group of women. Now that this group is satisfied, use increases only slowly. This could be true for example, if the largest part of the women using contraception were women with secondary education, who have a TFR level 2.6 and are the only ones according to the Lutz calculations which are controlling their fertility. If this is true, then the lower rates of increase would indicate that the group of well-educated women has been supplied with contraception, and the further increase is the slow diffusion among the rest of the population. This would indicate that the majority of the population has not been reached so far.

From 1991 to 1992, the contraception use rate increased fastest in the *conselhos* of Praia and Sao Vicente/Mindelo, the two largest urban areas. The contraception use in these cities is estimated to have increased from 35 percent to over 40 percent in the one year interval. By contrast, contraception use among women in Santa Catharina the *conselho* next to Praia, contraception use increased from 6.2 to 6.7 percent (Annual PMI/PF reports, 1991 and 1992).

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4.6 Conclusion

In this chapter, education, labor force participation and employment, women's status, dependence on agriculture, urbanization and the Cape Verde government's social programs are reviewed.

Education has been increasing continually throughout this century. In the colonial period as well as the period of independence since 1974 basic education increases preceded increases in the proportion of children continuing to secondary school. Since independence, the illiteracy rate has dropped from 60 to 25 percent, due to the education efforts of the Government and the large size and high relative weight of the well-educated younger cohorts. In the past, the education level of females was lower than that of males. Presently, it is equal to that of males in the cohorts under the age of 19. The public education expenditures per pupil and level increased only slowly from 1983–1987. The increase in public education expenditure in that period was largely due to a growing number of pupils.

The labor force participation rates among men, and particularly women, are high. Despite high fertility, the labor force participation rate of women is equal to that in industrialized countries, and 50 percent higher than in Mauritius in 1990. The employment of women is concentrated in agriculture, services, commerce, and construction. In agriculture and construction, women were largely employed in the low-income branches of the sector, namely rain-fed agriculture, and the poverty alleviation program in construction work, FAIMO. In total, 30 percent of the women were self-employed, compared to 21 percent of men. 91 percent of the self-employed women were equally distributed between agriculture and commerce.

The high labor force participation rates of women correlate to a social situation where 38 percent of the household heads are women and 39 percent of the women with children do not live in consensual union or marriage.

The number of people dependent on agriculture has remained almost constant since 1961. Population growth has been absorbed in non-agriculture activities. A part of these new activities remain in rural areas – to a large extent in the form of employment in the FAIMO. 54 percent of the population increase is in the urban areas. This transition out of agricultural activity and rural location is reflected in the rural-urban migration rates which are estimated to have been 2.3 percent annually during the drought in the 1970s and 1.4 percent annually during the 1980s.

Cape Verde supports roughly 9 percent of the population with direct food aid. Since 1983, there is a social security scheme which covered 22 percent of the nation's employees, and 17 percent of the total work force in 1994. The scheme is based on a pay-as-you-go system which will pay up to 80 percent of the employees last salary (ISPS, 1985:62). So far, few persons have received benefits due to the young age-structure of the population.

There is a basic health system which reaches 81 percent of the population within a one-hour walk to one of 99 health centers. Connected to this is the family planning program which was started in 1984 in conjunction with a maternal and infant health system. In 1992, there was a higher ratio of maternal and family planning centers per woman than in Mauritius in 1972, which was the middle of that country's fertility decline. Due to the lower population density of Cape Verde, the density of centers per square kilometer is considerably lower than in Mauritius at that time so that the actual accessibility of the centers in Cape Verde 1992 may be lower than in Mauritius 1972.

The contraception use rate increased at an average of 25 percent annually from 1984–1989, and slowed to 6 percent annual increase from 1989–1992. This may be due to the saturation of latent-demand in a sub-group of the population, which may be largely women with secondary education.

Chapter 5

Economy

5.1 Introduction

This chapter reviews the economy of Cape Verde in four parts: food production, other economic activities, macro-economic indicators, and foreign economic relations.

As the above chapters showed, agriculture or food production has been the economic backbone of the majority of the population. Although decreasing in relative importance, agriculture remains to this day the largest source of employment. Persons who are wholly dependent on agriculture or taking employment in the Government's FAIMO program in the rural areas (see Section 4.3.1) constitute the largest pool of poor people on Cape Verde.

This chapter analyses the productivity of different sectors of agriculture, namely rain-fed, irrigated and animal husbandry. It also discusses fishing, an important source of animal protein on Cape Verde. It evaluates the past record of agricultural production and the reforms which were to stimulate that production.

Agriculture is decreasing in relative importance as service and industrial activity on the islands increases. A brief overview describes other sectors of the Cape Verde economy, particularly two sectors which are promising for future growth, namely tourism and manufacturing. This section presents the input-output table of the Cape Verde economy.

The next section on macro-economic indicators discusses gross domestic product, private consumption, government expenditure, and investment. Gross domestic product is a less than optimal indicator of economic welfare in the population, particularly because it includes investments which do not benefit individuals. Private consumption, particularly, non-subsistence consumption are proposed as alternative indicators. The trends in gross national product and private consumption are compared.

This analysis shows that total domestic expenditures on Cape Verde exceeded gross domestic product consistently from 1973–1989. One result of this is a trade deficit. Imports and exports are discussed with regard to the trade deficit.

The trade deficit is financed by foreign funds. Previous chapters have pointed out the importance of remittances. There is a further source of foreign funds, namely public transfers, or, development aid. These two sources were up to 50 percent of the gross national product value in the period 1973–1992. The dependence on these sources is a major concern in Cape Verde. The decline in public transfers since 1985 is pointed out as a significant factor in the economic stagnation of the second half of the 1980s.

5.2 Food Production: Agriculture and Fishing

Agriculture has long been the backbone of Cape Verde's economy and still is the largest sector in terms of employment. As seen from the previous chapter on population, the agricultural sector of Cape Verde was usually able to provide sustenance to the population, but at regular intervals, drought caused crops to fail and famine ensued. Up until the middle of this century Cape Verde was food self-sufficient outside the famine periods. Since then, the food self-sufficiency has fallen to only one-third of food intake. The average per capita calorie consumption on Cape Verde

Table 5.1. Land use by type. Source: Forest calculated from Chamard and Courel (1992); agriculture from Lobin and Ohm (1987).

Land use type	Hectare 1990
Rain-fed agriculture	34 898
Irrigated agriculture	1 715
Pasturage	25 000
"Forest" in semi-arid areas	36 249
"Forest" in semi- and humid areas	6 472
Sub-total	79 334
Other	324 000

doubled between 1963 and 1990 (FAO, Agrostat), and the population size increased from 196 thousand in 1960 to 363 thousand in 1990. In the same interval, agricultural output barely increased in spite of the fact that the government has put through a number of land-tenure and land-reform laws that should have been conducive to investment in agriculture.

The agricultural output of Cape Verde is almost exclusively for domestic use. Exports are minimal. They include bananas, coffee, and a small number of other products. As was mentioned in previous chapters, there is a distinction between rain-fed agriculture and irrigated agriculture. The main crops on 35000 hectare of rain-fed agriculture are maize, beans, and sweet-potatoes which are inter cropped or rotated. It produces only a small fraction of the present consumption of staple cereals and pulses (between 4–35 percent per year from 1980–1993, average 15 percent, Program Alimentaire Mondial, PAM, 1994). Irrigation produces sugar cane for an alcoholic drink *grogue* on half of the irrigated area of 2000 hectares, and an assortment of vegetables and fruits on the other half. It is much less vulnerable to crop failure than rain-fed agriculture. Next to these two branches there is livestock. Livestock, like rain-fed agriculture, is sensitive to droughts. Cape Verde produces the fodder for these livestock domestically. The meat from livestock and the fish-catch together provide for most of the animal protein consumption on Cape Verde (comparison of meat and fish production with FAO statistics AGROSTAT on consumption).

Agriculture uses on only a small fraction of Cape Verde's total land area. That land which is not under cultivation is mostly steep mountains and dry steppes or savannas. *Table 5.1* shows the non-urban land use in Cape Verde, estimated for 1990 by own calculations. The total land area of Cape Verde is 4033 km^2. Only 600 km^2 are used for agriculture. Another 430 km^2 are used for forests which provide part of the nation's firewood and fodder.

The most productive agricultural islands are Santo Antao, Santiago, and to a lesser extent, Fogo. These islands have high mountain areas in common. The mountain areas provide higher areas which can expect more rain during the rainy season. In high altitudes, condensation of the moisture in the trade winds is often a more significant source of water than rain (see environment chapter). These islands also have the moist mountain valleys, the *ribeiras* where most of the irrigated agriculture is located. The three flat islands, Sal, Maio, and Sao Vicente have some pasturage.

There has been an enormous effort at reforestation on Cape Verde since 1975. The trees are to serve multiple purposes: most importantly to provide wood for cooking, also to provide livestock fodder, to combat erosion, and to create a micro-climate which holds more moisture.

Table 5.2 shows the gross value of irrigated and rain-fed agriculture, livestock and fishing in 1977 and 1993.

In 1977, 1852 hectares were irrigated compared to about 35000 rain-fed. The production of the irrigated hectares was 1510 million 1990 Escudos, and the production of the rain-fed agriculture was 1348 1990 Escudos. All together, *the irrigated hectares produced half of the total gross value of primary food products in 1977.* Rain-fed agriculture produced about 43 percent, pasturage only one, and fishing 7 percent (USAID, 1977, and Commissao Nacional, 1994).

Table 5.2. Agriculture and fishing gross value in 1977 and 1993. Source: USAID, 1977, and Commissao Nacional, 1994.

	1976			1993		
Type of agriculture	Hectare planted	Gross value mill.1990 Esc.	% of gross value	Hectare planted	Gross value mill.1990 Esc.	% of gross value
Irrigated	1852	1510	49	2124	2144	49 (est)
Rain-fed	35000	1348	43	33393	1739	40 (est)
Livestock		40	1		180 (est)	4 (est)
Fishing		209	7		255 (est)	6 (est)
Total		3108	100		4318 (est)	100

Between 1977 and 1993, there has been a 15 percent increase in irrigated hectares (less than one percent growth per year) and the production per hectare increased by 17 percent. The acreage of rain-fed agriculture did not change. The higher crop value in 1993 is due to better weather conditions. In 1993 there were four and a half as many heads of livestock as in 1974. The estimated fish catch in 1977 was 4000 tons (USAID, 1977:77) and in 1991 was 4884 tons (National Institute for the Development of Fishing, 1993:27). The values of livestock and fishing in 1993 are estimated on the assumption that the value of production is directly correlated with the number of animal heads and the tons of fish catch. With these assumptions, the total gross food production was worth 4318 million Escudos in 1993, of which 49 percent on irrigated land; 40 percent on rain-fed; 4 percent from livestock; and 6 percent from fishing. This is almost no change from 1977. In total, primary domestic food output increased 30 percent from 1977–1993. It did so equally in rain-fed as in irrigated agriculture. However, the rain-fed increase was due to better weather conditions, whereas the irrigation increase was structural as discussed below.

The rest of this section analyses livestock, irrigated and rain-fed agriculture production in relation to self-sufficiency.

5.2.1 Rain-fed agriculture

The production of the rain-fed agricultural sector on Cape Verde is risky because it is very irregular, depending on the variable rainfall and sometimes the destructive Harmattan wind from the Sahara. Farmers minimize their risk in a number of ways. One of the ways they minimize their risk is with the strains of crops they use. The farmers mix beans and maize, using low-yield but reliable strains – a different strain in each valley. Higher-yield maize are too picky for this climate. Another way is by spreading their activity out over a number of small plots. On the most populated island Santiago for example, 90 percent of the plots were less than 0.1 hectare large. However, one farmer may lease or own a number of them, spread out over a large area. For the overall productivity of the country's agriculture, this is a disadvantage, because the farmer has to trudge the long distances from one field to the next one. However, on an individual basis, this system makes sense because the farmer is spreading his or her chances of crop success over a larger area, one part of which may be blessed by rain.

Rain-fed agriculture produces the main supply of domestic cereals on Cape Verde, but is very sensitive to crop failure. From 1980 to 1992, according to the Program Alimentaire Mondial (PAM), the domestic coverage of cereals ranged from 4 to 35 percent. The average was 15 percent. The total consumption of maize, rice and wheat in 1993 was about 500 grams per person per day.[1]

5.2.2 Irrigated agriculture

There are presently about 2000 hectare irrigated land on Cape Verde. Half of this land is used to grow sugar cane. The other half is used to grow vegetables such as manioc, sweet potato,

[1] This provides an average of 1838 calories per person per day according tables in standard calorie tables.

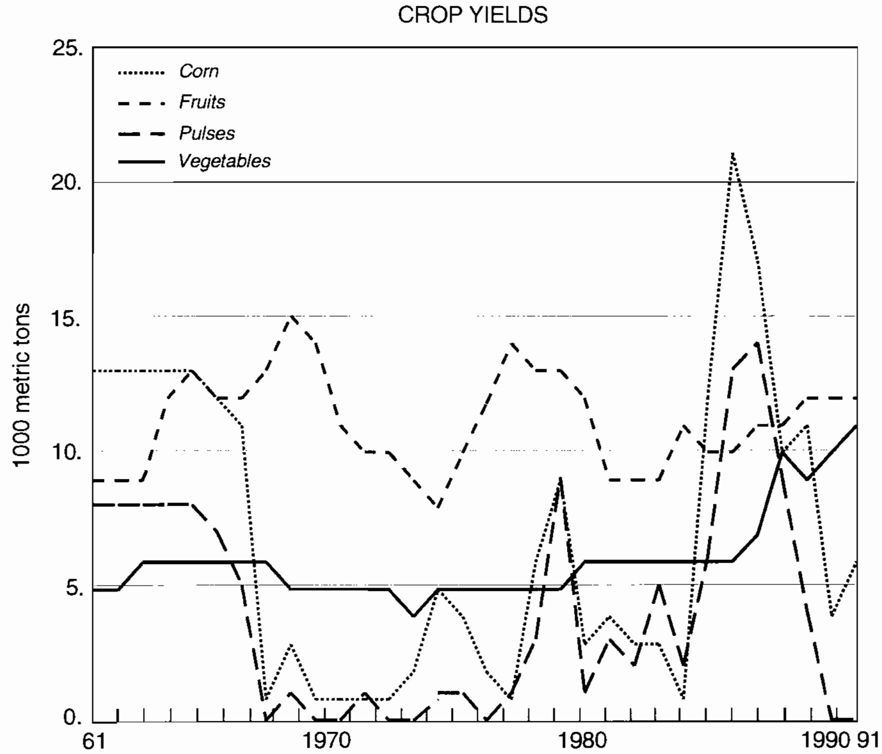

Figure 5.1. Yields of four important groups of crops on Cape Verde 1961–1992. Source: US Agriculture Service.

English potato, onion, tomato, cabbage. Banana trees grow on the irrigated land as well as dispersed other fruit trees such as papaya and mango.

The yields are relatively constant even in drought years. In the early days of independence, there were ideas to increase irrigated land from about 2000 hectare in 1990 to 8000 or 10000 hectare (e.g., USAID, 1977). More recent studies (Sellen, 1989) say that the maximum realistic increase to the end of the century is by 600–800 hectares.

The government has given the farmers incentives to change from growing sugar cane, which is used for the distillation of *grogue* the national alcoholic beverage, but without effect. There is considerable value added in the transformation from sugar cane to arguadente. As long as farmers can cook the arguadente themselves – the value added proceeds to them – sugar cane makes as much economic sense as vegetables – this because vegetables need more care than sugar cane so in the end it comes down to the same amount of work as making arguadente.

The production of fruits, largely bananas, was fairly constant from 1961–1992 at an average of 11000 tons. In recent years, the production of vegetables has increased continually from 6000 tons per year in 1988 to 11000 tons in 1992. Together, fruits and vegetables provide an average of 150 grams per person per day.[2]

Figure 5.1 shows the crop yields of the five most important food crops from 1961–1992, that is including good years and bad years, before independence and after. The figure shows the extreme variation in yields, particularly of the staples corn, roots, and pulses. The yields of fruits and vegetables, which are produced on the irrigated fields, did not decrease during the drought in the seventies. This shows that *irrigated agricultural output is consistent and dependable, independent of irregular weather conditions. Rain-fed agriculture is less independent of weather.*

[2]This is an average of 51 calories per person per day of vegetables (using potato, the most common vegetable as standard) and 74 calories of fruits (using the banana) according to tables in standard calorie tables.

Table 5.3. Heads of four important livestock on Cape Verde from 1987–1988. Source: Borowszcak, 1987, data 1897 to 1974; and Statistisches Bundesamt Deutschland, 1990; data 1986–1988; Commissao Nacional, 1994 for data 1990–1993.

Year	Cows	Goats	Sheep	Pigs
1897	13507	39446	9113	25017
1950	4789	18073	1102	6193
1968	41800	75000	3000	50000
1974	14000	45000	1500	24000
1986	12000	78000	2000	67000
1987	12000	79000	2000	69000
1988	12000	80000	3000	70000
1990	19191	109392	5544	98962
1991	16262	123745	6087	126548
1992	16891	133771	6683	161823
1993	17545	144610	7337	206931

5.2.3 Livestock

Livestock are dependent on droughts. After a low in 1974, the stocks of animals have increased again, particularly small pigs and goats, shown in *Table 5.3.* In 1993, the domestic fodder for these animals was sufficient, indicating true self-sufficiency.

If statistics are correct, then they show that Cape Verde has become more self-sufficient in the production of meat and presently produces 80 percent of its meat consumption. From 1961–1978 according to the US Department of Agriculture (USDA), only 1000 tons of meat were produced annually. In 1992, according to the same source 4000 kilos of meat were produced. This is equal to an average of 27 grams of domestic meat per person per day in 1993.[3] According to the Commissao Nacional (CN, 1994:Annex V), 1000 kilos of meat were inspected for import in 1993 indicating 80 percent meat self-sufficiency in the early 1990s. Cape Verde raised 700,000 heads of fowl in 1993 (CN, 1994) but data did not provide information about production and consumption of fowl and eggs.

The dependence on foreign milk is about 65 percent. According to the USDA, 2000 liters of milk were produced from 1961–1992, compared to 3862 imported in 1993 (CN, 1994).[4] The stock of milk-producing livestock, cows and goats, varied considerably in that time. One hypothesis to explain constant milk production, variable livestock numbers, and large milk imports is that the capital to process milk into products that can be preserved, e.g., dry or condensed milk, is limiting the production of milk, rather than the domestic ability to raise livestock.

The data indicate that Cape Verde is largely self-sufficient in meat production, but less so in milk production. A part of the milk dependence may be related to a lack of capital to process milk into dry, condensed or other form that is simple to preserve in a tropical climate.

5.2.4 Incentives and disincentives to increase agricultural production

Before and after the drought, that is pre-1968 and post-1985, the absolute food production of Cape Verde appears to have been similar, in spite of land reform changes and water improvements since 1974.

In order to improve the agricultural output the government of Cape Verde has: created a land-reform, thus far mainly improving tenancy regulations; built terraces to counter erosion and increase acreage; increased the water supply with reservoirs and pipelines; introduced price incentives to increase the production of vegetables. An FAO research center is studying improved

[3]This is an average of 53 calories according to an average of different pork sorts provided by standard calorie tables. The 700,000 fowl on the islands are estimated to provide an average of one half egg per head equal to just under one egg per person, or, 60 calories per per person per day.

[4]The 2000 tons of milk prodnced domestically are equal to an average of 13 grams per person per day which provide an average of 8 calories per person per day.

varieties of plants better suited to Cape Verde and Cape Verde's pests. Recently drip irrigation has been installed by a number of farmers with considerable success.

There have been a number of land reform phases since 1974. Borowczak (1987) divides the land reform from 1974–1987 into three stages. The first phase of land reform was consolidation of the government control of the reform over spontaneous grass-roots actions. In the second period 1975–1982 the first laws that share-cropping should be replaced by money-rent were enacted. This was often not implemented because the tenants did not see it in their own interest (could not afford the risk of a money rent in drought years).

The third phase after 1983 was to implement a new law "land to those who build on it". Tenant contracts would be for life, as long as the tenant cultivated the land and would be hereditary. In due course, the government would buy the land from the present owners. This reform has proceeded slowly, in part to avoid offending the many owners who are émigré Cape Verdeans and send remittances home.

There are a number of reasons the land-reform may not have led to higher yields. Presently, the land-ownership situation continues to be unclear. This is a disadvantage for, many investments in farming take a long time to mature – maybe 50 years in the case of trees – and are only thinkable when one's lease on the land is similarly long and secure. Besides this, rain-fed farming is risky on a year to year basis. Finally, the system is coming to depend on food from outside. The domestic market is neglected. Then, in years with large crops, e.g., 1986/7, some of the harvest lies fallow on the land because there is no infrastructure to transport it to the markets.

A major constraint remains the availability and the distribution of water. Studies (Sellen, 1989; Krüger, 1988; Viereck, 1987) show that productivity on present irrigated land could be almost doubled through better water distribution and subsequent different crop mix, with the same amount of water.

The water on Cape Verde is unevenly distributed in nature and in human ownership. Water from the private pumps and springs is sold to the farmers by the owner. The water from the state owned pipelines is cheaper, but the watering hours, dispensed by the state-employed *motoradore* are less flexible. Private water provision dominates on Sao Antao while public water dominates on Santiago and Fogo. Very few farming lots are behind small dams where water collects naturally, without human distribution.

The farmers receive water for a number of hours in rotation. According to the 1988 agricultural census the average length of water availability is about 1 hour per rotation. Per 0.1 hectare, a farmer receives about 20 m2 water per hour. The intervals between rotation turns at the time of the census were long. On Sao Nicolao, the median interval between rotation was 23 days and the median length 48 minutes; on Sao Antao, the median interval was 38 days and median length 49 minutes; on Santiago, the median interval was 21 days with 69 minutes, on Sao Vicente the median was an 8 day interval with 55 minutes water.

This has consequences for the choice of crops grown on the irrigated land. Unless he or she can build, e.g., a cistern to store water, a farmer with longer time intervals needs to grow crops that can go for long periods without water. The crops on Cape Verde which grow best under these conditions are sugar cane and bananas. Vegetables need water weekly or bi-weekly, so the farmer with long watering intervals cannot grow them even though they would bring much more profit. Besides this, vegetables must be brought to market in a relatively short period of time.

In a simulation model of agriculture, Sellen (1989) showed that profit maximizing, rational farmers would grow sugar under these conditions, and would only change to other crops if they received water more frequently. However, he did not consider the installment of private cisterns per lot from which the farmer could then take water as needed.

One new development is that in recent years the production of vegetables on irrigated land and the use of drip irrigation has increased. This has happened simultaneously with the introduction of a large number of motor vehicles on the islands. Now that there are motor vehicles, the produce can be brought to the market quickly. This may be part of the reason that

Table 5.4. Annual fish catch in tons, total catch, and small-scale fishing catch only. Source: SBD, 1990 and Insituto Nacional de Desenvolvimento das Pescas, 1993.

Year	Total catch in tons	Small-scale fishing catch in tons
1983	11864	11890
1984	10730	6855
1985	10190	7120
1986	6483	4764
1987	6941	4005
1988	6073	4092
1989		6391
1990		4935
1991		4884

the production of vegetables increased continually from 6000 tons per year in 1988 to 11000 tons in 1992.

5.2.5 Fishing

In contrast to its land resources which are few, Cape Verde is in a very productive part of the ocean namely, one of the so-called "rising areas". These are located on the west coasts of Africa, Peru and California. This is where the wind blows the surface water away from the coast. This creates suction for nutrient-rich water which rises from the depths of the ocean. The water is full of plankton. In these areas edible fish abound. These rising areas take up only 0.1 percent of the ocean surface, but are the source of 50 percent of the world's ocean fish catch. Much of this fishing is industrial, with huge factory ships, belonging to the 12 large industrial nations. Recently, the world-wide fish catch has been decreasing, and there are signs that this is due to over-fishing the oceans with the industrial ships.

The major commercial fish caught in Cape Verde seas are tuna and mackerel which migrate in and out of Cape Verde's territorial waters and which are subject to heavy industrial fishing by the industrialized nations. On the sea bottom, there are lobsters which are Cape Verde's own resource. Most of the fish catch, however, is species which are caught for domestic consumption and Cape Verde is self-sufficient in its fish consumption.

According to Pálsson (1990):

> The fishing resources included in Cape Verde's 200-mile economic zone appear to be considerable, but fisheries output is still fairly low. More than two-thirds of the total catch is landed by small-scale fishermen while the remainder is caught by a small but expanding industrial fleet. [Pálsson:96]

The fish catch increased from an estimated 4000 tons in 1977 to almost 12000 tons in 1983. It *decreased* from 1983 to 1987 as *Table 5.4* shows. It is not clear what caused this. The small-scale catch declined parallel to the total. In 1991, the artisanal catch was almost 5000 tons (compared to almost 12000 in 1983), equal to an average of 34 grams of fish per person per day.[5]

It is tempting to believe that the richness of the waters in Cape Verde's 200-mile economic zone offer an easy possibility to expand production and exports. In principle, Cape Verde cannot compete with huge industrial ships in the Atlantic Ocean which process the fish on board. On the other hand, the Cape Verdean fishermen can return to the mainland with their catch, where it can be processed on land. Then, such large ships as the industrialized nations have would not be necessary. There has been an increase in the commercial fishing fleet – in 1977 there were 3

[5]This is an average of 82 calories of tuna, which constitutes most of the fish catch provided by standard calorie tables.

ships over 100 tons; in 1987 7; in 1988 8 – however, with no parallel increase in catch. One likely explanation for this could be that the area's supply of tuna fish is decreasing due to over-fishing by the industrial ships.

It is also argued that the productivity of small scale subsistence fishing could also easily be increased, simply by providing better rods, or small outboard motors. However, if the small-scale fishing is for *limited* subsistence needs, increased productivity might only reduce the number of hours worked, but not, increase the catch – as actually occurred in Maio (Watanabe 1981:4 in Pálsson 1990:105). The fact is that people will only eat so much fish. If there is no external market, fishing will not increase, except in proportion with the population or in case of drought and limited alternative food.

Another possibility to make use of the marine wealth in these rich waters is mare-culture – raising shrimps, oysters, lobsters, and mussels (Wachenfeldt *et al.*, 1987). This option is not further explored in this study.

5.2.6 Conclusion for food production

This analysis shows that Cape Verde produced 11000 tons of the 17000 tons of animal produce consumed in 1993 excluding fowl products, which indicates it is largely independent in animal protein. It is estimated this provided almost 250 calories per person per day on average.

The country is also largely self-sufficient in fruits and vegetables, which provided 22000 tons in 1992, and a rounded 100 calories per person per day.

In terms of calories provided, this food self-sufficiency 9 percent of the calories consumed per person per day in 1992. In terms of value however, it is closer to 30 percent. This food self-sufficiency pattern which is concentrated on animal proteins, fruits and vegetables while missing carbohydrate and oil production is similar to that observed in Mauritius.

5.3 Non-agricultural Activity

As is evident from the employment figures in Section 4.3, three large sectors next to agriculture are: construction, commerce, and personal and community services. These sectors produce largely for the domestic economy. Two economic sectors which presently contribute under 10 percent to gross national product and less in terms of employment, are tourism and manufacturing. The potential importance of these sectors is that they could expand into large sources of export revenues.

This section discusses these sectors in order.

5.3.1 Construction

Construction is by far the largest industrial sector which produced 80 percent of the industrial value added in 1980 and 60 percent in 1988. It is by nature an investment sector: in buildings, roads, conservation works. On Cape Verde, construction investment in roads and conservation works is public, largely via the FAIMO. It was hypothesized in chapter 4 that employment in the FAIMO fills a structural gap between a growing rural population and a stagnating agricultural sector.

The private portion of construction is in housing and other buildings. According to local sources, emigrants finance a large part of the housing construction.

5.3.2 Commerce

Commerce is a largely domestic activity and most strongly associated with selling agricultural and manufactured products (see the importance of commerce in these sectors in the columns of the input-output *Table 5.6*). It was a fast growing sector from 1960–1990. In 1960, only 1403 persons registered themselves as employed in commerce, in 1980 it was 3930, and in 1990 it was

12747 (ILO, 1989 and 1993). As discussed in Section 4.3.1, most of the increase was among self-employed women, the market-sellers, or *rabidantes*. It has been observed in other countries that the informal service sector, of which commerce is an important part, has increased quickly in other developing countries and it has been hypothesized that

> [High population growth] together with high rates of rural out-migration, allowed urban labor force growth to outstrip the absorptive capacity of industry. The surplus labor thus generated entered the service sector, and engaged in largely low-productivity, individual and family enterprises ... [Pandit and Casetti, 1989:333]

This indicates a causal connection between fast labor force growth facing Cape Verde, a slow growth in formal employment opportunities in the country, and an increase in the informal commerce sector.

5.3.3 Personal and community services

The personal and community services sector on Cape Verde was dominated by 68 percent employment in the public sector at the census 1990, which includes those who are working in public schools, public health centers, and the national and local governments. The government expenditures, which are all in services, increased at a rate of 12 percent annually from 1974–1986 which is the period the country was setting up its national government. From 1986–1988, government expenditures remained constant in real terms. This trend, together with the decreasing employment in the FAIMO since 1986, show that the *government of Cape Verde has not been compensating for the tension between economic slack and labor force growth in recent years.*

5.3.4 Tourism

Tourism has been growing in recent years on Cape Verde. Cape Verde is a beautiful country with fantastic landscapes, and a safe one, and as such, it has tourism potential.

Tourism is not counted as a separate sector in the national accounts. However, various indicators show that the sector has grown in the past few decades. In 1980, hotels and restaurants were an insignificant sector. Value added was 124 million 1990 Escudos (0.07 percent of GDP, DGE, 1991:22). In 1988, it was 470 million 1990 Escudos.[6] This was 1.8 percent of GDP (*idem*). The number of hotel beds increased from 782 in 1985 (DGE, 1989:142) to around 1600 in 39 hotels in 1990 (BKA, 1993:40). Income from airline services also increased considerably from 1980–1988 from 130 million 1990 Escudos in 1980 to 1101 million in 1988. Not all of the income from the hotels and restaurants, nor the airlines, nor the non-resident expenditure is from tourism as these activities also include business and family trips, and domestic consumption of hotels and restaurants.

In comparison, in a country like Mauritius, generally acknowledged as a "tourism success", tourism generated an estimated 38 million US$ in 1987[7] and 69 million US$ value added in 1991 including income from flights. The number of occupied nights in hotels on Mauritius was 2372 thousand in 1987 compared to 131 thousand in 1000 beds on Cape Verde in the same year. If tourist income per night was the same in Cape Verde in 1987 as in Mauritius, this would indicate that the tourism revenues in 1987 were 2.1 million US$, or, 147 million 1990 Escudos. This would indicate that Cape Verde has quite some way to go. However, Cape Verde has only one-third of the population of Mauritius. Therefore, on a per capita basis only 23 million US$ would be "needed" in Cape Verde to make it as "successful" as Mauritius was in 1991.

[6] The export value of tourism indicated by the expenditures of non-residents in the country, was 243 million 1990 Escudos in 1980 and 444 million 1990 Escudos in 1988 according to the Direccao de Estatistica Geral. The slower growth of non-residents than the estimated growth of the tourist sector is because non-residents includes the non-resident emigrants.

[7] The product of 1991 revenues with the ratio of 1987/1991 employment in the tourism sector provided in Ramsamy, 1994:179–180.

From 1987–1990, the number of hotel beds expanded from 1000 to 1600 (Bundeskanzleramt, 1993:40). Assuming the occupancy rate is the same as in 1987, and revenues equal to 1987, this would indicate 210 thousand occupied hotel nights, and 3.4 million US$ tourist revenues in 1990. Considering there has been expansion since then, it could be that on a per capita basis Cape Verde's tourism sector is well on its way to "Mauritian success", but the data are not yet available to confirm this guess.

In conclusion, total tourism revenues are difficult to estimate. The values indicated by the sums of revenues from hotels, restaurants, and airlines are higher than those from calculations using bed occupancy and an income per bed equal to that of Mauritius. Using the former data, tourism income would have been in the range of 885 million 1990 Escudos (13 million US$) in 1987; in the latter it would be 147 million 1990 Escudos (2 million US$). Tourism income in Cape Verde would have to be 1600 million 1990 Escudos (23 million US$) to be "equal" to "Mauritian success" at its 1991 per capita level.

Like some other tourist countries (e.g., Greece, Mauritius), the development of the tourist sector is potentially hindered by water shortages. In Cape Verde, the island with the most tourism, Sal, is also the island with practically no fresh water. The bigger hotels there have their own desalination facilities.

5.3.5 Manufacturing

Manufacturing has been weak in terms of employment and value added as a portion of gross domestic product. In 1988, only 5 percent of value added and employment was from manufacturing. Comparatively, on Mauritius in 1987, 30 percent of value added and 28 percent of employment was in manufacturing.

An analysis of the manufacturing sector by branch in the national accounts (DGE, 1993) shows that until 1988, most manufacturing production was for domestic use.

The national accounts (DGE, 1991:22), which publish value added by detailed sector, show that in 1980 there were *fewer* manufacturing sectors than in 1988, and that they were smaller. Existing manufacturing sectors in 1980 were: fish conserving, bakeries, tobacco, clothing, carpentry, printing, ship repairs, and small artisan works. By 1988, the bakery, tobacco, carpentry and ship repairs had expanded considerably, and a beer and soft-drink factory had been set up and production of shoes, pharmaceuticals, paint and other construction materials had begun. Virtually all of the increases in manufacturing had been for the domestic market.

Until 1988, the government policy was to support small scale industry producing for domestic needs. To a certain extent then, this was successful. From 1988 however, the government has changed to a more export oriented policy. This change was further strengthened by the new government after 1991.

The government has not set up an export processing zone (EPZ) as in Mauritius, although various incentives for export industries have been implemented. In 1994, the first fruits of this change, two Portuguese shoe factories in Mindelo, were apparent. Various analyses (Coopers and Lybrand, 1991, Bundeskanzleramt, 1993) point out the lack of a sufficiently well-educated labor force, little entrepreneurial skills, and relatively high costs as causes for the slow start. However, it should be pointed out that on Mauritius, there was a ten year lag between setting up the EPZ and the textile boom which started in 1987. Moreover, as the Mauritian experience shows, although manufacturing would generate a large amount of employment, its dependence on foreign intermediate products makes the actual net gain the country in terms of value added much lower than the gross output values. In conclusion, following the Mauritius example, *one could say that the initial growth of manufacturing is slow and takes some years to mature before it can be successful.*

Table 5.5. Matrix of economic sectors used in PDE Cape Verde model by dominant characteristics.

	Dominated by private enterprises		Dominated by public enterprises	
	Production for domestic market	Production for export market	Production for domestic market	Production for export market
Primary production	Agriculture[a] Mining			
Secondary production	Manufacturing	Manufacturing	Energy and water Construction	Transport and communication
Tertiary production	Commerce Commercial services	Hotels and restaurants[a] Transport and communication	Government services	

[a]Intense water users.

5.3.6 The economic niches of different sectors

The discussions above show that each economic sector thus far discussed has its own niche in the economy. Agriculture is a private primary sector, manufacturing a private secondary, and commerce a private tertiary which produce largely for the domestic market. Manufacturing also has the potential of being important for export. Construction is a secondary sector for domestic production which has a large public portion. Tourism is a tertiary sector geared to exports. *Table 5.5* shows 11 sectors of the Cape Verde economy in the cross-tabulation primary, secondary, tertiary, by public, domestic, private, and export orientation.

A summary of the economic role of each of these 11 sectors is given in the input–output table. The input–output table

> ... summarizes the complex web of transactions between firms and customers, and firms and other firms in the economy. If the buyer is a final user, who consumes the good, we are talking about final demand. Final demand is shown in the right-hand side of the table in the columns labeled "consumers", "government", "investment" and "exports". If the buyer is another firm, this is domestic "intermediate demand". Domestic intermediate demand is shown in the [11 × 11] matrix of the sectors in the upper left portion of the table. The rows of [11] sectors indicate to whom the output of each sector was sold. The columns of the [11] sectors indicate the input into each sector's product. Below the [domestic] intermediate demand matrix are [two] rows for imports. [Wils, 1994:236–237]

The latest input–output table of Cape Verde was made for the year 1988 and is shown in *Table 5.6*. The bottom two rows show value added in each sector and gross total output. Value added is the actual domestic product which comes from domestic activity.

The table shows that in terms of value added, the largest 5 sectors in Cape Verde in 1988 were, in order: commerce, agriculture, transport and communications, construction, and government services. Transport and communication, which is not a major sector in terms of employment, is a large export sector, probably related to the transportation services rendered by Cape Verde in unloading imported materials. The largest sector in terms of gross output is manufacturing, but half of the gross output is from imported products and almost one-quarter is from commerce (see the column of manufactures in *Table 5.6*).

5.4 Macro-economic Indicators

In spite of agricultural stagnation, and slow industrial growth, Cape Verde's gross national product grew at an average of 4.8 percent annually from 1974–1989. This was largely due to increases in construction, commerce, and government services which contributed 75 percent of the growth from 1974–1989.

Table 5.6. Input–output table of 1988 with 11 sectors. From more extended table provided by the DEG.

	O1	O2	O3	O4	O5	O6	O7	O8	O9	10	11	Int.Dem	C	G	I	Stock	Ex	Total
O1 Agriculture	234	0	946	0	93	0	158	0	0	0	48	1478	7692	0	277	-244	163	9365
O2 Mining	0	1	2	0	179	0	1	0	0	0	0	183	12	0	0	3	4	203
O3 Manufacturing	334	6	1040	31	2548	105	176	484	42	16	635	5416	9536	0	3211	7	350	18520
O4 Energy and water	50	5	105	503	134	41	40	639	17	13	139	1686	944	0	0	-398	1937	4170
O5 Construction	0	0	0	0	0	0	0	0	192	0	6	198	0	0	6049	0	0	6248
O6 Commerce	2506	11	4114	1084	3	0	3	478	44	96	-272	8067	0	0	0	0	0	8067
O7 Hotels and restaurants	1	0	5	1	0	2	8	46	5	0	101	170	732	0	0	0	111	1012
O8 Transport and comm.	1	2	51	10	117	1748	8	1147	17	6	328	3436	1563	0	0	0	2440	7439
O9 Finance and housing	90	4	82	11	62	146	20	153	216	14	67	866	2074	0	0	0	52	2991
10 Commercial services	23	0	55	12	336	12	15	83	46	15	1265	1862	165	0	0	0	0	2027
11 Non-commercial services	0	0	0	0	0	0	0	0	0	0	0	0	116	4672	0	0	0	4788
Domestic intermed. cons.	3240	30	6399	1651	3472	2053	428	3032	580	161	2318	23362	22833	4672	9537	-633	5058	64830
Imports	938	7	9182	2178	0	0	118	1175	185	1636	0	15418						
Import duties	53	0	1482	82	0	0	0	0	0	0	0	1618						
Intermediate consumption	4231	37	17063	3911	3472	2053	546	4206	765	1796	2318	40399						
Wages	334	85	586	125	2342	872	158	1231	254	97	2521	8606						
Indirect taxes	1	0	81	1	2	134	4	18	0	3	1	245						
Subsidies	0	0	13	70	15	26	0	8	0	0	0	131						
Surplus	4800	80	777	62	416	4984	304	1975	1972	130	0	15500						
Value added	5135	165	1457	258	2776	6015	466	3232	2226	231	2522	24483						
Gross total output	9366	202	18520	4169	6248	8068	1012	7439	2992	2027	4840	64882						

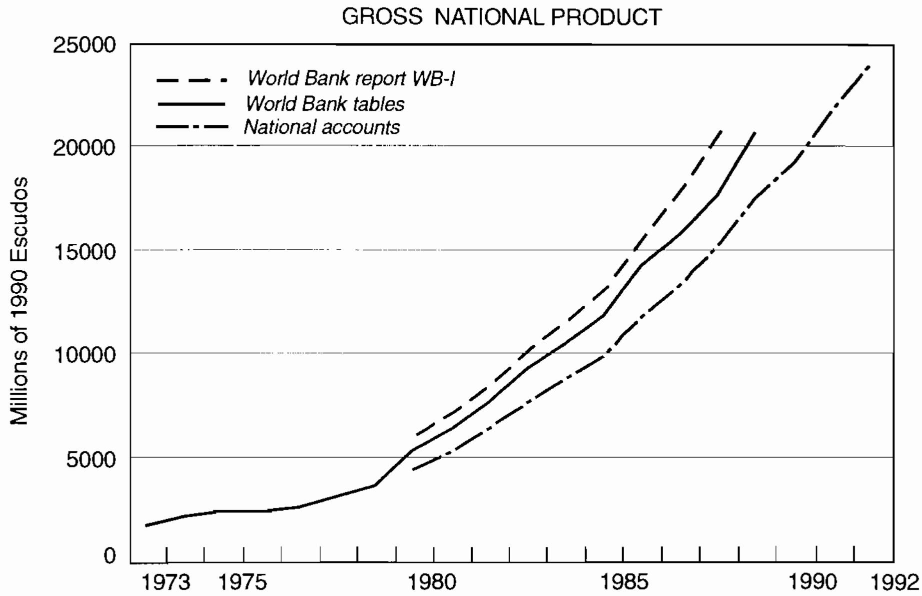

Figure 5.2. Gross domestic product in Cape Verde from 1973–1992 according to three different sources, World Bank Report (1994), World Bank Tables (1993), and National Accounts (DGE, 1991).

Gross national product was 9507 million 1990 Escudos in 1970 according to the World Bank (1993). It decreased to 8223 million 1990 Escudos in 1974, and since then, increased almost linearly to 23565 million 1990 Escudos in 1989 according to the World Bank (1993). According to the national accounts (DGE, 1991), gross national product was higher, and according to a country-report by the World Bank, gross national product was lower than these estimates. The difference between the high and the low estimates is up to 25 percent of gross national product. The estimates are shown in *Figure 5.2.*

The World Bank Table estimates, which provide the longest time-series, and which is the middle estimation, is used in the rest of this study to approximate gross national product and other macro-economic indicators.

Gross domestic product is an estimate of the economic activity in a country in a given time period, but it may not be the best indicator for the population's economic, material well-being because it includes economic activities such as investments or environmental conservation works. These investments do not directly affect the amount of money a consumer has in-pocket to fulfill his or her or the family's needs and desires. It is possible that when investments are very high, they may actually *subtract* from the private consumer's in-pocket if for examples: taxes are raised to pay for public infrastructure improvements, or environmental conservation; or if companies leave less profit dividends due to high investments. Gross domestic product also includes government expenditure. Whether or not government expenditure raises private consumer economic well-being depends on what the government provides, and is a matter of ongoing political debate.

It is therefore proposed to use private consumption as an alternative indicator of a population's economic well-being, and to divide this consumption into subsistence consumption, which is the minimal necessary for bare survival, and non-subsistence, variable consumption, which actually measures material surplus for individuals. *Figure 5.3* shows the development of subsistence consumption and variable consumption in Cape Verde from 1973–1989. Subsistence consumption is approximated by taking the mean of the World Bank cut-off points for "poor" and "ultra-poor" in Cape Verde (World Bank, 1994). For comparative purposes, gross domestic product is included.

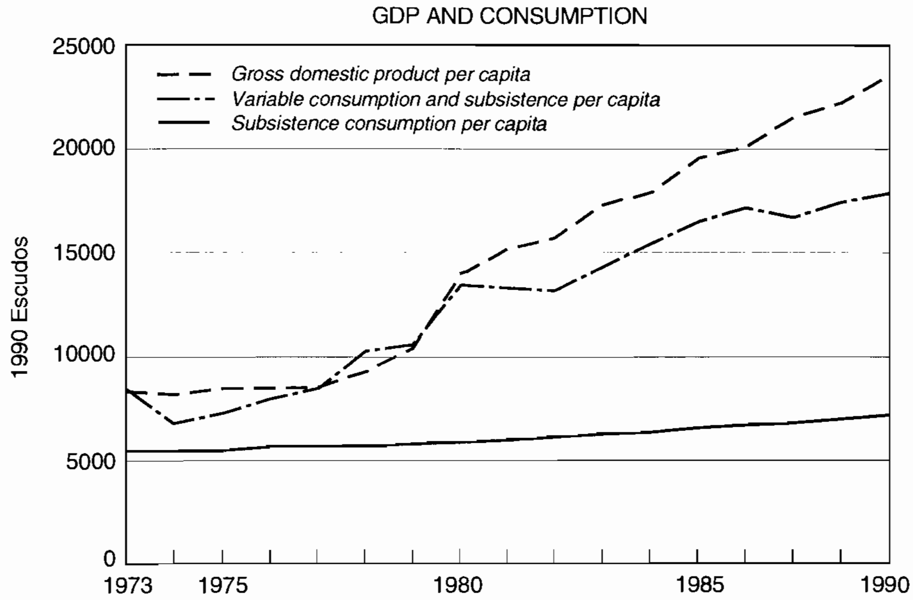

Figure 5.3. Subsistence consumption, variable consumption, and gross domestic product from 1973–1989, using World Bank (1993) economic data. All data in 1990 Escudos.

The figure shows subsistence consumption increasing slowly, at exactly the same rate as population and considerably more slowly than gross domestic product and variable consumption. Variable consumption, which is the difference between total and subsistence consumption increases fastest from 1974–1980. The rate of increase is an average of 13.2 percent annually. For the private consumer on Cape Verde, this entailed a very fast increase in tangible wealth. Much of this increased consumption was financed by remittances as is shown below.

In the period from 1980–1989, variable consumption increased only 3.7 percent annually, more slowly than gross national product. One reason for this slow-down may be that remittances no longer increased. Remittances remained at a constant average real level from 1982–1989 with annual fluctuations. Another reason is that investments and government expenditures increased relative to private consumption, leaving less of the given pool of funds for private consumption.

Figure 5.4 shows gross domestic product and private consumption as in *Figure 5.3.* The figure additionally shows total domestic expenditure, which includes private consumption, plus government expenditure, plus investments. The difference between total domestic expenditure and private consumption is government expenditure and investments. It is evident from the figure that the sum of government expenditure and investments increased relatively little from 1973–1980, and thereafter from 1980–1986 take up most of the increases in domestic expenditure.

The figure also shows that total domestic expenditure is consistently above gross domestic product. The gap was widest in 1986, and between 1986–1989 decreased. The reason such a gap can exist is income from abroad in the form of remittances and public transfers. This income is spent on imported products because the domestic products are only available up to the value of gross domestic product. Thus, the expenditure gap is directly related to the trade balance of Cape Verde.

To a certain extent, the value of gross domestic product itself is related to the trade imbalance and income from abroad. A certain amount of domestic economic activity, which adds to gross domestic product, is a recycling of foreign income and imports. For example, two-thirds of construction employment in 1990 was in the FAIMO, which is funded by selling food-aid or by

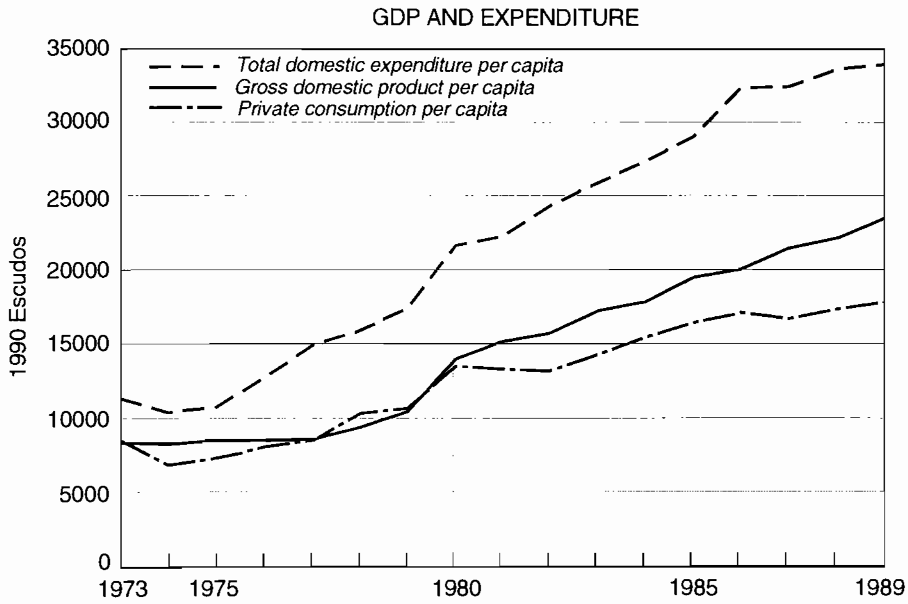

Figure 5.4. Total domestic expenditure, gross domestic product, and private consumption, from 1973–1989, using World Bank (1993) economic data. All data in 1990 Escudos.

other development aid. Half of the commerce activity consists of selling manufactured products of which the value is two-thirds imported.[8]

The next section discusses Cape Verde's trade balance and the role of remittances and public transfers.

5.5 Foreign Economic Relations

5.5.1 The historical trends of the trade balance

Cape Verde, a small economy with a tiny domestic market, is very open. That means that a large proportion of its gross domestic product is spent on imports and a large portion comes from abroad as discussed above – through exports, workers' remittances and official transfers. With the workers remittances and the official transfers, the balance of payments of Cape Verde has remained roughly in balance. Most economies however, are judged by their balance of trade – the balance of exports to imports. The balance of trade says how much a country generates *internally* to pay for the goods it buys from abroad. Here, Cape Verde is very unbalanced.

Inferring from information given in historical sources, the balance of trade was probably more balanced in the past up until the 1950s, than it is presently. However, incoming foreign funds – say, through remittances – are usually translated into imports. If the incoming foreign funds are not from exporting, then this results in a deficit on the trade balance. Cape Verde has received remittances for almost two centuries now. Either these compensated for expropriation by the colonizers or there has been a long history of a skewed trade balance in the archipelago.

According to Carreira (1982), imports increased greatly during the 1960s. Exports on the other hand, according to Carreira have been decreasing throughout the century and probably reached a low just before independence.

The increase in imports continued in the 1970s and 1980s but only in proportion with overall income. In the years 1985–1988 the proportion of income spent on imports decreased. Theoretically, this could be the result of economic distress, of greater domestic production, of

[8]Total gross output in manufacturing minus commerce intermediate input in manufacturing – is used as an estimate for actual manufactured gross output. This is equal to 18520-4114 = 14406. Of this, 9182 was imported, or, 64 percent.

Table 5.7. Exports and imports 1980–1990 by major type, according to national accounts (DGE, 1991) in million 1990 Escudos.

	Exports				Imports				
Year	Agric. exports	Transp. & comm.	Tourism	Total	Fuel	Non-fuel mat.goods	Transp. & comm.	Other services	Total
1980	577	1844	243	2664	910	8029	328	633	10125
1981	636	2657	287	3581	1120	8669	375	1186	11577
1982	396	2780	361	3536	1325	9252	373	2148	13308
1983	462	3375	381	4218	1345	10357	439	1904	14300
1984	366	3338	357	4061	1492	10641	422	1950	14787
1985	873	3178	378	4428	1767	10995	683	2475	16215
1986	502	2592	386	3481	1337	10833	623	2250	15339
1987	765	2473	416	3654	1239	10486	837	2387	15262
1988	304	2831	444	3579	706	10168	1016	2466	14690

a shift in production to sectors which use less imports, or an income redistribution away from groups which spend a large portion of their money on imports. It is true that there was an economic slump 1985–1989, but there was not a decrease in income, so one would not expect a decrease in imports. What we do see however, is a large decrease in foreign aid in these years. This would seem to best explain the reduction in imports. Much technical foreign aid consists in bringing machines to Cape Verde such as wind-mills, toilets, bio-gas production centers, construction material for dams. A reduction in aid would automatically translate into a reduction in imports if all else stayed the same.

Exports from Cape Verde are traditionally primary products, but in fact, the largest value of exports has been from services at least since independence. The islands used to export Pulgeira nuts which were used for lighting oil, until 1960 (Carreira, 1982:33). During the 1960s, exports were mainly fish (fresh and frozen), bananas, peanuts and salt (USAID, 1978:30). In the last years of colonialism exports decreased consistently, to a low of almost zero in 1975, the first year of independence. During the first 5 years of independence, the export of services increased tremendously, mainly transportation services, and since 1980 these stabilized around a value of 3000 million 1990 Escudos. The primary products remain at a fairly stable, low level. Tourism is the sector which is clearly increasing throughout the 1980s. Although statistics are not yet available, it is evident that tourism has continued to increase in the years from 1988–1994 as discussed in Section 5.2. The exports of manufactures as also discussed in Section 5.2 was not evident yet in 1988.

Table 5.7 shows the imports and exports by major sector from 1980–1988 according to national accounts in million 1990 Escudos. Fuel and non-fuel material goods barely increased from 1980–1988. This parallels the stagnation in consumption found in Section 5.3. The import of services increases. The input–output table shows that these are private services bought by the government. Column 11 of *Table 5.6*, the input–output table, shows that the government spent 1265 million 1990 Escudos for commercial services. Commercial services in turn, as column 10 shows, consist almost wholly of imports – the services of foreign consultants.

Figure 5.5 shows the obvious gap between imports and exports. Probably for over a century, Cape Verde has been buoyed by remittances from Cape Verdeans abroad. Since independence a large flow of international aid has doubled the amount of money coming in from abroad.

5.5.2 Workers' remittances and foreign aid

Remittances increased in the 1970s and 1980s, and remained constant in real terms from 1982–1991. Public transfers increased enormously from independence to 1984 in current Escudos and real terms, and decreased by about 50 percent in real terms from 1984–1991.[9]

[9] Appendix x discusses the estimation of the value of official development assistance.

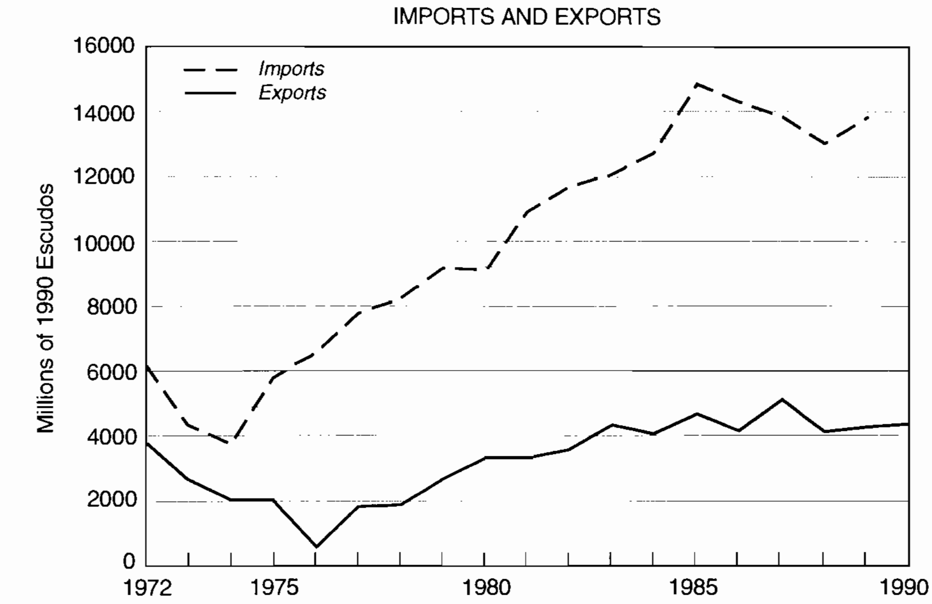

Figure 5.5. Imports and exports from 1972–1990 in Cape Verde. National sources.

According to the World Table estimates, remittances and public transfers peaked at 69 percent of GDP in 1977, a year when exports were also practically zero, two years after independence, in the tenth consecutive drought year. During the whole first decade of independence, these transfers remained around half of GDP. From 1983–1989, the ratio has decreased considerably from .69 in 1977 to .30 in 1989.

Figure 5.6 shows public transfers, the sum of remittances and public transfers, and gross domestic product. The figure shows the increase in the foreign transfers from 1973–1986. Thereafter, foreign transfers decrease. Gross domestic product continues to rise. The difference between gross domestic product and the transfers is an indication of the "real" strength of Cape Verde's economy, independent of foreign transfers. It is obvious from the figure that the "domestic strength" of the economy has been growing particularly since 1986, in spite of a domestic and international (e.g., World Bank, 1994) impression that the economy stagnated in the late 1980s.

5.6 Conclusions

This chapter analyzed agriculture, non-agriculture sectors, macro-economic indicators, and the foreign economic relations of Cape Verde.

It showed that the rain-fed agriculture increased since independence. Livestock has increased since independence as it recovered from the drought. Irrigated agriculture stagnated until 1988 when the production of vegetables began a consistent increase, leading to a 40 percent increase in output from 1977–1992.

An analysis of the stagnation of agriculture shows that the water distribution system in the irrigated areas is such that only sugar cane and bananas are possible to grow without investments in cisterns and other individual irrigation structures. It was hypothesized that these investments were not made in the past due to inaccessibility of the market. Since the introduction of large numbers of motor vehicles, this impasse may have been overcome.

In 1993, Cape Verde was largely food self-sufficient in the consumption of animal protein. The country produced 80 percent of the meat it consumed (4000 out of 5000 tons), but only 35 percent of the milk and milk products (2000 out of 6000 tons). It was self-sufficient in the consumption of fish (5000 tons in 1991). The country was also producing almost enough vegetables for domestic production. However, it was not at all self-sufficient in the production

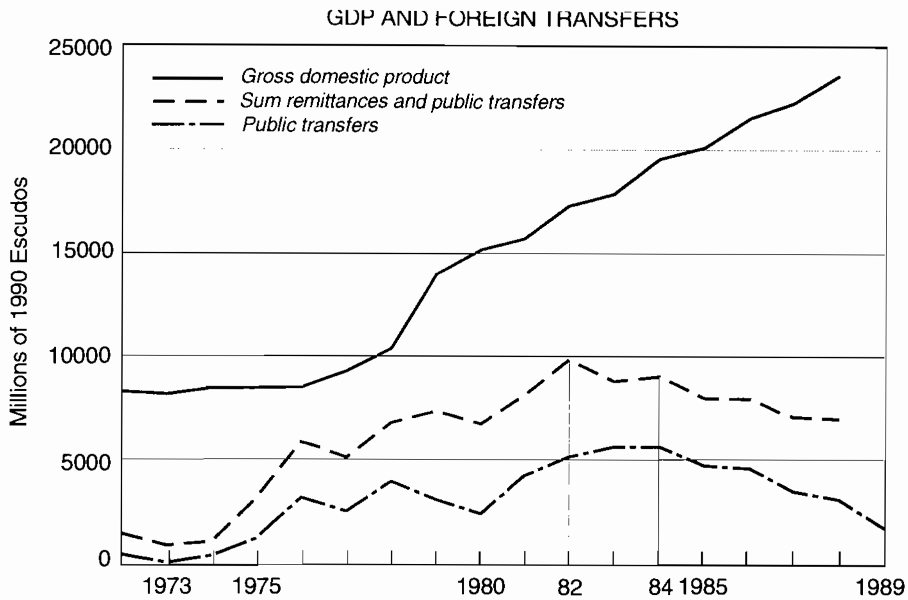

Figure 5.6. Public transfers, remittances, and gross national product from 1973–1989 according to World Bank data (1993) in million 1990 Escudos.

of cereals and other carbohydrates. This food self-sufficiency pattern is very similar to the one found in Mauritius.

Total tourism revenues are difficult to estimate but indicate an increase during the 1980s. The values indicated by the sums of revenues from hotels, restaurants, and airlines are higher than those from calculations using bed occupancy and an income per bed equal to that of Mauritius. Using the former data, tourism income would have been in the range of 885 million 1990 Escudos (13 million US$) in 1987; in the latter it would be 147 million 1990 Escudos (2 million US$). Tourism income in Cape Verde would have to be 1600 million 1990 Escudos (23 million US$) to be "equal" to "Mauritian success" at its 1991 per capita level. At the least, in 1990, tourism was at a level equal to 15 percent of the Mauritian 1991 per capita level.

From 1974–1988 the national policy was to increase domestic production. To a certain extent, in the production of bread, furniture, shoes, paint, tobacco, and soft-drinks, this was successful. The increase in manufacturing exports was just beginning in 1994, six years after the initialization of an export oriented policy. However, such a lag was also observed on Mauritius. Following the Cape Verde and Mauritius cases, it appears that the *initial growth of export manufacturing is slow and takes some years to mature before it can be successful.*

Variable consumption increased at a very high rate from 1973–1980, and since is growing more slowly than gross national product. In part this is explained by the stagnation of remittances form 1982, and also because investments and government expenditure continued to increase.

The trade balance of Cape Verde is strongly negative, and became more negative from 1974–1984. The trade deficit was largely paid for by foreign aid transfers and remittances. These foreign transfers were up to 69 percent of gross national product since independence (peak in 1977). They have decreased in real value and as a proportion of gross national product since then. In 1989 they were equal to 30 percent of gross national product.

Since 1982 remittances stagnated and from 1984–1990, the real value of foreign aid transfers decreased by 50 percent. Gross national product increased at lower rates of growth since 1982 than from 1974–1982. A significant part of this slower growth is due to lower foreign transfers. The "real strength" of the Cape Verde economy however, independent of foreign transfers, may have increased more quickly from 1984–1989 than in the decade before.

Chapter 6

Environment

6.1 Introduction

The preceding chapters on population, economy and social development have shown that for various reasons, the natural environment of Cape Verde contributed to its history, and still contributes to its development. The location of the islands made them attractive to colonize in the first place as a depot for the slave trade. They are located halfway between Europe and Brazil, and on the sailing route which is prescribed by the dominant ocean winds – namely to follow the North-East Trade wind down along the coast of Europe and North Africa and across the Atlantic ocean to the Americas. The whale resources in the territorial waters invited whalers from the United States to come and this initiated the emigration which has become such a central part of the Cape Verde culture and economy. The paucity of water and the regular droughts probably contributed to the fact that the Europeans who could, left the islands early in the colonial period. It also contributed to the fact that farming remained largely a subsistence activity, rather than that plantations dominated agriculture as in other colonies. The reason there is so little water has to do with winds – Cape Verde is just outside the moist monsoon path. The geography of the islands is such that most of the land is difficult to use productively, but that there are a few fertile valleys The steady trade winds blow the wind-mills which pump up water to irrigate the fields in these valleys. Today, the paucity of water still makes development difficult, as each factory, or hotel, or housing unit requires more costly investments to provide the necessary water than in other countries. The geographical distribution over nine small islands makes the diffusion of new ideas difficult, and this may contribute to the slow acceptance of family planning methods on some islands. The beauty of the islands makes them attractive for the tourist sector which is becoming a more important part of the economic structure.

This chapter gives more attention to what is without doubt presently the most important natural resource on Cape Verde: water. It is important not because of its abundance or quality, but because of its scarcity.

The chapter begins with a description of the geography and the winds which blow on the islands, the two main factors that determine the rainfall. Of itself, the air blowing over Cape Verde is relatively moist. It then describes the different climates on the islands which have determined where agriculture and what kind of agriculture is possible. The third section describes the water use on Cape Verde and the man-made water distribution system. The following section describes the costs of obtaining water with different methods. Matching the water demand and the water supply in the most cost-effective way is a difficult challenge for the country which the scenarios in chapter 8 explore.

The final section concerns the natural vegetation and the reforestation efforts on Cape Verde. Reforestation has more than an ideal value, in that the trees directly provide fuel for cooking and forage for animals. It is possible that they indirectly provide enough shade and moisture for forage grasses to grow in their protection and that they increase the detention of rainfall with their foliage cover and their roots. In many mountainous countries, the water-regulating function is one of the most important contributions of forests to human society. Studies on the increased water detention on Cape Verde were not found.

Table 6.1. The inhabited islands of Cape Verde, size, and maximum altitude.

Island	Size (km^2)	Maximum altitude (m)
Santo Antao	779	1979
Sao Vicente	227	774
Sao Nicolao	388	1304
Sal	216	406
Boa Vista	620	390
Maio	269	436
Santiago	991	1392
Fogo	476	2829
Brava	67	976
Total	4033	2829

6.2 Geography, Winds, Rainfall, and Climates

6.2.1 Location and size

The Cape Verde archipelago is located a about 600 kilometers west of Senegal and is considered part of the Sahel countries. It has ten islands, of which 9 are inhabited, and 5 islets, grouped into a dented horseshoe shape opening to the west. See map in front cover. Altogether, the islands have a surface of 4033 km^2. Their topography varies from mountainous to flat. *Table 6.1* lists the islands, going from the north-west of the horseshoe clockwise around, by size and maximum altitude.

The islands are of volcanic origin. This is reflected in the rugged contours of some of the islands – notably Santo Antao and Santiago – and in the typical volcano shape of Fogo. Three of the islands – Sal, Boavista, and Maio – are relatively flat. Two further important characteristics of the volcanic origin are the fertility of many of the soils on the islands, in those places where there are soils, and the natural aquifers formed during the periods of volcanic activity which are the population's main source of water.

6.2.2 Winds

The archipelago is very windy. There are three winds which blow: the north-east Trade wind, the Sahara Harmattan, and the Atlantic Monsoon from the south-west. The dominant wind is the north-east Trade which makes up 80 percent of the winds (Lobin and Ohm, 1987:306). The north-east Trade wind is moist. When it reaches the mountainous islands, the wind is forced upward along the mountain-sides. At altitudes around 1000 meters the moisture in the air condenses to rain, but often more importantly, to fog and dew fall. In these humid areas the rainfall averages 900–1100 mm/year, and experiments with dew-catching nets indicate an equivalent of around 900 mm/year of moisture from dew and fog.[1] At higher altitudes and on the leeward side of the island the Trade wind is dry because it has given off its moisture. The low islands do not benefit in the form of rain or dew from this wind's moisture.

The Harmattan, 6 percent of the winds, is a harsh, dry, dusty sandstorm which blows intermittently in the period from November–March directly from the Sahara and covers the islands in a fine reddish-brown dust. It can destroy crops.

Very important for the archipelago is the Monsoon, which makes up only 5 percent of the winds (*idem*). The archipelago is located, like the rest of the Sahel, on the northern edge of the annual migration path of the inter tropical convergence which brings the monsoon and rain. The convergence moves northward and the Monsoon can reach Cape Verde in July and

[1] There exist experiments to trap this moisture in nylon nets. In one such program, an average of 2.5 liters per m^2 per day were collected over a period of 10 months. This translates to about 900 mm of moisture annually, which is certainly more rainfall than in most years (Courel and Chamard, 1992:241).

Table 6.2. Average rainfall by island per year.

Island	Annual average rainfall (mm)
Santo Antao	237
Sao Vicente	93
Sao Nicolao	142
Sal	60
Boa Vista	68
Maio	150
Santiago	321
Fogo	495
Brava	268
Total	227

August. Then, it can cover the islands in short, torrential rain-bursts. In many years however, the monsoon does not travel north enough to reach Cape Verde, or only to reach some of the islands, and in these years, drought occurs.

The strong and constant winds are a useful source of energy, which has traditionally been used on Cape Verde to pump up ground water, and which is presently being further developed for that same purpose, and for the generation of electricity.

6.2.3 Rains

Altogether, the rain in Cape Verde is characterized by unequal distribution. It is distributed unequally by geography, between the years, and within the year. The average rainfall on the islands in 227 mm/year. The wettest island, Fogo, receives 495 mm/year, and the driest, Sal, 60 mm/year. *Table 6.2* shows the average rainfall per island.

Within the year, the rain is very unevenly distributed, and is concentrated in August and September. In total 60 to 80 percent of the annual rain falls in August and September alone. Even this rain is concentrated in a few days of torrential deluge. Comparatively, the two wettest months on the nearby Canary islands give only 42 percent of the total rain.

Annually, the rain varies. At Praia, Santiago, measured rainfall from 1875–1977 varied from zero in 1970 to almost 1000 mm in 1907. *Figure 6.1* shows the annual rainfall from 1875 to 1977. The figure shows the regular drought periods with little or no rain for one or a sequence of years, and a slight decrease in average rainfall from the middle of this century (USAID, 1978).

6.2.4 Climates

The topography, the winds and the rains result in different regional climates within the archipelago. These have been classified by various researchers (e.g., Texeira and Barbosa, 1958; Klug, 1980; Brochman and Rustan, 1987). A simplified classification is given below:

1. Humid zones. These have more than 400 mm/year rainfall regularly, plus dew condensation. Generally, they have a better distribution of rain within and between years than elsewhere on the archipelago. In these areas, cultivation of crops is possible in 8 out of 10 years. They are located on the north-west side of the islands with higher altitude, notably, Santo Antao, Santiago, and Fogo. In these zones there are approximately 500–600 hectares which are accessible enough to be suitable for agriculture (FAO, verbal).
2. Semi-arid and semi-humid zones. These areas have more than 400 mm annual rainfall in 4 to 7 years out of ten. These are located around the humid zones and in the north-west middle of the other islands.
3. Arid zones. These areas have more than 400 mm annual rainfall in 0 to 3 years out of ten. About 60,000 hectares are scheduled to be reforested in these zones with drought resistant

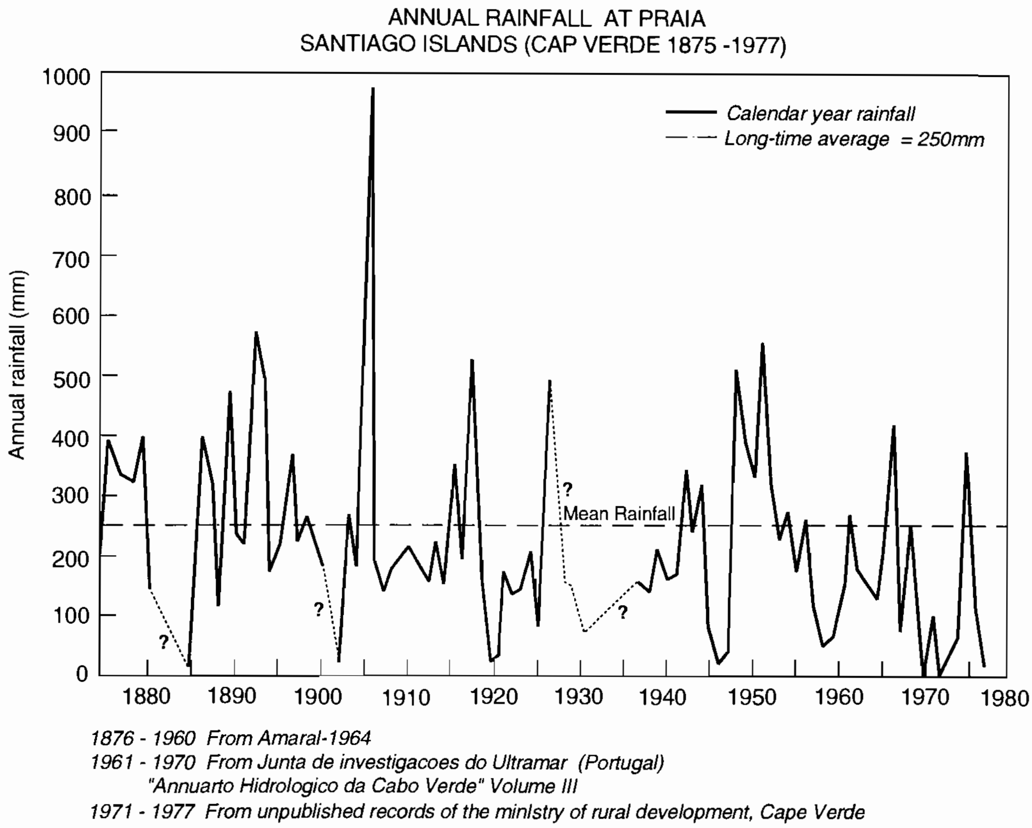

Figure 6.1. Annual rainfall from 1985–1977 in Praia. Source: USAID, 1978.

trees by the year 2000. From 1975 to 1990 a total of 35,000 hectares was reforested in the arid zones with drought resistant trees, 80 percent of total reforestation. It is impressive to see the thousands of small, protected trees growing among the stones. Once larger, the trees retain rain to seep into the ground water, provide wood for cooking, and a moister micro-climate where grasses grow for forage under their foliage.

4. The humid and fertile *ribeiras*. These are mountain valleys, usually opening to the coast, which collect run-off rain and soil from the mountainsides. These areas have natural alluvial springs which have been supplemented by wells and bore holes. Here, the circa 2000 hectare irrigated agriculture is located.

6.3 Water Use and Supply

6.3.1 Amount of water available

With an average of 227 mm rainfall a year, and a surface area of 4033 km^2, the total rainfall on Cape Verde averages 925 million m^3 of water. An estimated 67 percent evaporates, 20 percent is lost in the oceans as run-off, and 13 percent, or 124 million m^3/year (rounding errors, INGRH, 1993a:3.14), annually recharges the ground water. It is estimated that about half of this ground water is exploitable, but that during a dry period, the exploitable volume decreases further to 44 million m^3 per year. This estimation, made in the light of new knowledge, is lower than earlier estimations of ground water recharge and accessibility, e.g., Fernandopulle (1977, in USAID: 1978:73) estimated 176 m^3 recharge annually. The 44 million m^3 exploitable ground water in dry periods is also much lower than the 181 million m^3 "available water" shown in the UNDP (1994). The exploitable ground water resources are distributed among the islands as shown in *Table 6.3.*

Table 6.3. Ground water resources by island in average and dry periods (in million m^3/year). Source: INGRH, 1993b.

Island	Average	Dry period
Santo Antao	21.3	14.5
Sao Vicente	.4	.2
Sao Nicolao	2.5	1.5
Sal	.0	.0
Boa Vista	.7	.3
Maio	.9	.5
Santiago	26.0	16.5
Fogo	12.0	9.3
Brava	1.6	1.0
Total	65.4	43.8

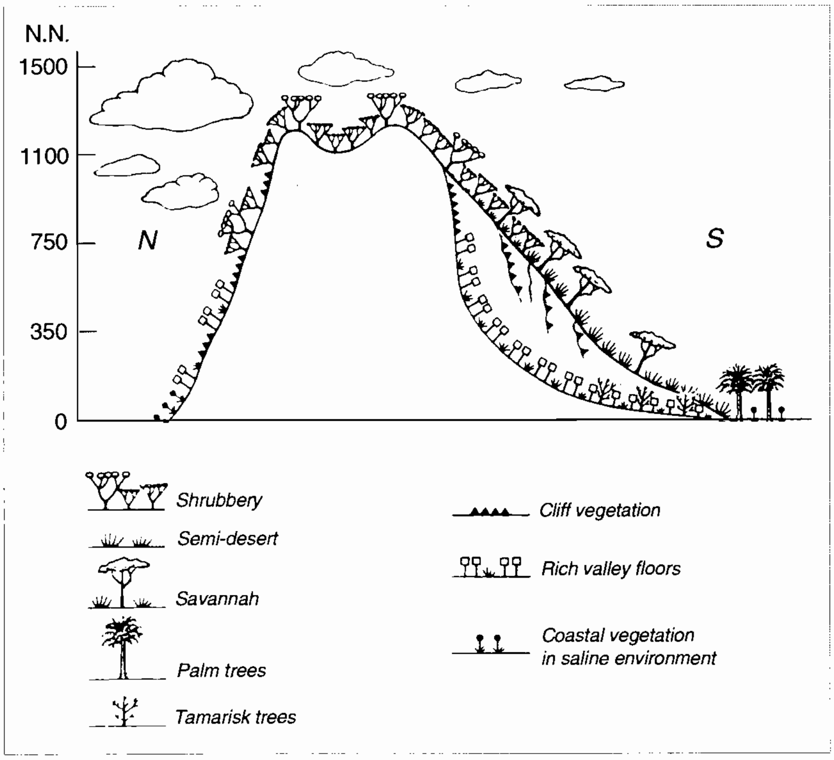

Figure 6.2. Idealized figure of the natural vegetation on a typical Cape Verde islands.

These ground water resources represent most of the reliable fresh water resources that Cape Verde can count on presently, that Nature retains on the islands as it were. Most of the rest evaporates or is lost in floods to the oceans. There are very few perennial rivers, nor are there natural or man-made reservoirs for surface water.

With the 1990 population of 363 thousand this 44 million m^3 translates to 121 m^3 per capita annually, or 332 liters per person per day. Although this is theoretically sufficient with sparse domestic and industrial use and careful irrigation, it is a narrow margin considering for example the 121 liters used on average per capita daily in Mauritius, and up to 250 liters per day for those with 24 hour in-house water service (Ramjeawon, 1991:281).

6.3.2 Water use

An estimated 36 million m^3 of water was used in 1990 in Cape Verde. This is about the same amount as was used in the middle of the 1970s (Fernandopulle, in USAID, 1978). Most of the water – about 85 percent in 1990 - is used for irrigation. Only a small portion is used for domestic, service and industrial purposes and for animal husbandry.

According to the 1990 population census, 65 percent of the population uses the public drinking water supply, either through indoor plumbing, by taking the water from public fountains, or by truck delivery. The rest of the population, mostly in the rural areas, takes its water from other sources such as natural springs or private wells.

The distance to the public fountains in 1990 was found in a UNICEF inquiry (1993). It was found that 18.2 percent of the population had no access to a public water source; 8.5 percent lived more than 2 kilometers away from a public water source; 3.7 percent within one to two kilometers; and 54.3 percent within one kilometer. The remaining 15.3 percent take water from an indoor plumbing system. In total, 70 percent of the population lives within one kilometer of a public fountain. Some people use private sources of water, either "because of easier access to a traditional water source, excessive distance between home and distribution point, the cost of distributed drinking water, or a combination of these factors" (INGRH 1993:R.14).

The average daily per capita consumption of water in 1990 is low. It was 47.6 liters for 54000 users with in-house supply and 14.2 liters for 156000 fountain clients and 11000 people to whom water is delivered by truck. The rest of the population, 120000 people use traditional sources to obtain their water and the average daily consumption was not measured.

According to these figures, 4942 m^3 of water are consumed daily from the official distribution network, in-house, through fountains, and trucks.. According to the INGRH (1994a) 5700 m^3 are distributed daily. The discrepancy could be due to water losses or irregularities in measurement.

The INGRH estimates the actual household needs were 7500 m^3 in 1990, of which 34 percent was coming from private use. The domestic water requirement is projected to increase from 7500 m^3 daily in 1990 to 12000 m^3 daily in 2005 considering population increase and the elimination of use from traditional sources. The population in 2005 according to the UN is going to be 540000 people. This means the average projected water use remains constant at 22 liter per person per day.

Water on Cape Verde is costly, and consumption varies with income, according to the 1989 Household Survey (DGE, 1989). In that household survey one percent of total household expenditure on Cape Verde was on water or 380 Escudos per person per year (DGE, 1989:29). With an average paid-for water usage of 14.2 liters per day, or 5.2 m per year, this indicates an average cost of 73 Escudos per m^3. The expenditure on water differs considerably from island to island. According to the survey, the per capita annual expenditure on water in Santo Antao was 70 Escudos annually, compared to 1040 Escudos on Sao Vicente, 8 percent of the total expenditures of households on that island.

In order to arrive at an estimate for water demand depending on population and income, water demand is divided conceptually into subsistence demand which is a direct function of population size, and private consumption dependent. The subsistence level is taken to be the 14.2 liters used presently by the fountain clients. Annually, a person then would require 5.1 m^3 of water. At the average cost of 73 Escudos in 1988/9, this is 379 Escudos.

The island Sao Vicente, with hardly any private (free) sources of water is taken as an example. On Sao Vicente expenditure (approximation for income) was 47780 Escudos per inhabitant in 1988/9 according to the Household Survey. Expenditure on water was 1040 Escudos. Of this, 379 Escudos is estimated to be on subsistence water consumption, leaving 661 Escudos, or, 14 Escudos for every 1000 spent. With this, .2 m^3 of water can be bought. In this calculation, for every 1000 Escudos of per capita income, average annual water demand increases by .2 m^3.

Total water demand per person for household purposes is then estimated to be:

$$WD = 5.1 + .2/1000 \text{ Escudos per capita income} \quad (6.1)$$

Table 6.4. Estimated water demand for commercial purposes on Cape Verde by sector using Mauritius 1989 water demand as a standard. Data for Mauritius published in Toth (1993).

Sector	Value added 1988	First estimation: m^3 water used/ mill.1990 Esc. production[a]	First estimation: 1988 water demand in mill.m^3	Second estimation: m^3 water used/ mill.1990 Esc. production[b]	Second estimation: 1988 low water use demand
Manufacturing	1169	122	0.14	122	0.14
Energy and water	208	10	0.00	10	0.00
Construction	2228	29	0.07	29	0.07
Commerce	4830	32	0.16	16	0.08
Hotels and restaurants	374	344	0.13	344	0.13
Transportation	2595	17	0.05	9	0.03
Finance	1787	7	0.01	4	0.01
Private services	185	60	0.01	30	0.01
Government services	1993	62	0.12	31	0.06
Total			0.69	0.53	

[a] 1989 Exchange rate via dollar exchange rate provided by World Tables, as well as 1989–1990 price index increase in Cape Verde, Mauritian water use standard. Cubic meters used per million 1989 Mauritian Rupees production in Mauritius is: Manufacturing 556; Energy and Water, 44; Construction, 134; Commerce, 147; Hotels and Restaurants, 1562; Transportation, 79; Finance, 34; Private services, 272; Gov't services, 282.
[b] 1989 Exchange rate via dollar exchange rate provided by World Tables, as well as 1989-1990 price index increase in Cape Verde.

where *WD* is per capita water demand. With this calculation, the estimated water demand on Sao Vicente is 14 m^3 per year, close to the actual 13 m^3.

The non-agricultural commercial water distributed was 1470 m^3 daily or .54 million m^3 per year. This is all the water used for manufacturing, construction, in offices, hotels and transportation. The sector specific unit (per million Escudos output) commercial water demand was not available for Cape Verde. Mauritius unit sector water demand is used as an estimate for Cape Verde's. Putting the Mauritius water use per million 1990 Escudos output into the Cape Verde 1988 sectoral output results in a first estimate of water demand. *Table 6.4* shows the value added by sector, the Mauritius standard water demand per million 1990 Escudos output, and the hypothetical water demand.

Using the "Mauritius standard" gives an estimated .69 million m^3 commercial water demand, compared to .54 million m^3 actually distributed. This is close considering the differences in water availability and economic structure between the two countries. The biggest over-estimation of water use is likely to be in services. The Mauritius water authorities estimated that the daily use of water per employee was 40 liters. This is twice as much as the average Cape Verdean uses in total. Taking only one-half of the Mauritius standard water demand in services brings the total commercial water demand down to .53 million m^3, almost exactly equal to the actual use.

For irrigation, according to the 1988 Agricultural Survey (MRDP, 1991) most of the water – 61 percent – comes from springs emitting from alluvial aquifers and flows to the plots by gravity (MDRP, 1991:123). 17 percent is water pumped up by human technology from wells and another 5 percent from galleries. In spite of the lack of surface water 11 percent of irrigation is with river water and 5 percent with water caught behind small dams. Only 22 percent of the water for irrigation is sold to the farmers by the government (INGRH 1993). Some of the water percolates back into the ground water.

An estimated 32.7 million m^3 was used to irrigate in 1990 (INGRH, 1993b:R.18). Of these, an estimated 4.5 million m^3 percolated back into the ground water. Considering the 16 percent of the surface area irrigated with surface water from rivers or trapped by dams, another 6 million m^3 are provided by surface water. This results in an estimated 22 million m^3 of ground water consumed by irrigation in 1990.

Table 6.5. Gross water use by major category of user and the source of supply, the return to ground water, and net use, estimated for 1990, in millions m^3/year. Data adapted from INGRH, 1993b, and MDRP, 1991.

	Water source and type of distrubtion						
	Surface	Desalin.	Ground water		Returned		
User	water Private	Central distrib.	Central distrib.	Private or other	to ground water	Net ground water use	Gross total
Domestic indoor			.94[a]				.94
Domestic outdoor			.87[b]	.62[c]		2.15[h]	1.49
Service and ind.			.54[d]				.54
Irrigation	≈6.00		7.20[f]	19.50[e]	4.50	22.20	32.70
Animals				.58[g]		.58	.58
Total	≈6	1	10	21	5	25	36

[a]47.6 l/pp/day × 54 000 persons with indoor water × 365 days/year/1000, INGRH, 1993b:R.13.
[b]14.2 l/pp/day × 156 000 persons nsing fountains + 11 000 persons using truck × 365 days/year/1000, idem.
[c]14.2 l/pp/day × 120 using other sources × 365 days/year, idem.
[d]1470 m^3/pp/day × 365 days/year INGRH, 1993b:R.16.
[e]78% × 32.7 million m^3/year, INGRH, 1993b.
[f]22% × 32.7 million m^3/year, INGRH, 1993b.
[g]1600 m^3/day × 365 days/year, INGRH, 1993b:R.19.
[h](.94 + 1.49 + .54) water use - .8 desalinated central water supply, INGRH, 1993b:R.30,R.33,R.34 and others.

Table 6.6. Ground water use and desalination by island in 1990, in millions m^3/year. Source: calculated from INGRH, 1993b:diverse pages.

Island	Ground water	Desalinated water
Santo Antao	11.2	
Sao Vicente	.4	.6
Sao Nicolao	1.0	
Sal	.0	.2
Boa Vista	.08	.02
Maio	.2	
Santiago	11.4	
Fogo	.5	
Brava	.3	
Total	25	.82

According to the 1988 agricultural census, there were almost 200000 farm animals and almost 200000 fowl on Cape Verde. Their water provision is usually from natural sources, estimated at .58 million m^3 water annually.

Table 6.5 shows the gross water use by major category of user and the source of supply, the return to ground water, and net use, estimated for 1990. The use of water differs per island reflecting the population size, the economic activity, and especially, the extent of irrigation. *Table 6.6* shows the use of ground water and desalinated water by island according to the INGRH in 1990.

6.4 Water Resource Development, Costs, and Management

Water resource development on Cape Verde is costly. An estimated 90 million US$ were invested in the water sector from 1980–1989, 12 percent of all investments in the period.

This section describes different modes of increasing the distribution capacity of water, and makes estimates of the costs.

Table 6.7. Reservoir at Trinidad to serve Praia, proposed versions. Total annual costs are in million US$ and include pay-off for the investment in 5 years at 4 percent interest in 1993 prices. Source: Möller, 1994.

Proposed reservoir volume (mill.m^3)	Annual piped water capacity (mill.m^3)	Total investment (mill.1994 US$)	Total annual costs incl. maintenance (mill.1994 US$)	Total costs per m^3 of water (1994 US$)
2	1.42	n.a.	.88	0.62
4	1.80	18	.97	0.54
10	2.20	27	1.39	0.63

6.4.1 Ground water mobilization

Ground water mobilization by digging wells, drilling bore holes and galleries is the most frequent measure of increasing the water distribution capacity until now. In 1990 there were 6300 bore holes, wells, and springs (INGRH, 1993:R6) in Cape Verde. The wells are open and go down to the ground water which is taken out by hand in buckets. Water from boreholes is pumped up mechanically.

The costs per m^3 of obtaining ground water vary depending on the difficulty of reaching the ground-water. The investments costs for a present project at Praia which includes drilling 4 wells and construction of a system of adduction by gravity are 7.2 million US$. This project is estimated to provide 1500 m^3/day or, .55 million m^3/year annually. Next to such large projects there are many small ones which are of vital importance in the rural areas. One such project is the construction of 68 wells and 23 reservoirs with a daily capacity of 4000m^3/day or 1.46 million m^3/year for 6.8 million US$ (INGRH, 1993b:Table 17.03). This means that the costs of reaching the ground water vary from $4.60 to $13.00 at least per m^3 if installed capacity.

The costs of maintenance also vary. The costs of maintaining the pumps were estimated to vary between 13400–156000 Escudos (168–1950 US$,[2] INGRH, 1993a:3.20).

6.4.2 Catching surface run-off

Another way to increase water availability is to catch the surface run-off. This can be done by building constructions to trap the water in the ground, called contour rock walls or check dams, or by building dams for actual reservoirs.

The contour rock walls keep the water from running off. The water caught behind the wall seeps into the ground. There, it keeps the ground moist so it can be cultivated (see, e.g., Lopes and Meyer, 1993:55).

Catchment and recharge check dams are larger than the above and go down to the bedrock. In this case the run-off also seeps into the ground but is trapped between the dam and the bedrock. At the bottom of the dam it can be pumped or drained out and piped or channeled downstream to be used.

A number of possibilities exist to build reservoirs. One site proposed for such a dam is west of Praia at Trinidad. Plans for this reservoir exist for three versions: 2, 4, and 10 million m^3. The actual annual water available from the reservoir is much less than the capacity because of the concentration of rainfall in short periods and evaporation in the intervals. *Table 6.7* shows the capacity, the estimated usable water total costs and costs per m^3 of water for the three proposed varieties. The costs are $10.00–$12.27 per m^3 of installed capacity.

[2] Exchange rate used throughout the publication: 80 Escudos = 1 US$.

6.4.3 Desalination

Desalination of the sea water is the only alternative on a number of islands with almost no ground water resources, or where there is a high population concentration as in the capitol, Praia. The present capacity for desalination is .82 million m^3 annually. The costs, including the investment pay-off, are estimated to vary between 2.50 and 5.00 US$ per m^3 of water. It is one of the more expensive alternatives. The plans are to double present capacity on Sao Vicente to 1.3 million m^3/year; to increase the capacity at Sal by 0.1 million m^3/year; on Boa Vista by 55 thousand m^3/year; to install desalination capacity for Praia around 0.5 million m^3/year (INGRH, 1993). This means an increase in desalination capacity from 0.8 to 2.2 million m^3/year.

6.4.4 Fog condensation

Another source of water is fog condensation. The North-East Trade wind is moist and the moisture condenses on the hillsides. In some parts of the mountains of the archipelago, this condensation is a more important source of water for plants than rain. Experiments on Santo Antao during 10 months found that 2.5 liter of water could be captured per day per m (Courel and Chamard, 1992), which is equal to 912.5 liter per year, or almost a cubic meter of water per year per square meter. The costs of water which could be obtained from fog condensation are difficult to estimate.

6.4.5 Rationalizing irrigation water

The most important way to increase the water availability is to rationalize the irrigation system. It presently uses an average of 12–15 thousand m^3 of water annually per hectare which can be halved by installing a storage system so water can be used when needed rather than when available; and by installing a drip irrigation system. The costs for installing a storage and a drip irrigation system are estimated to be 400 thousand Escudos by INGRH per hectare (1993b:R.18). Other sources (FAO, verbal) estimate the investment costs to be significantly lower. Comparatively, the present costs of irrigated production are about 120 thousand Escudos annually per hectare; and the net surplus – before water costs – about 425 thousand Escudos per hectare (INGRH, 1993b:R.17). Installing a drip irrigation system is therefore only rational if a higher surplus can be expected. According to chapter 5, drip irrigation allows the production of high-value vegetables, but doing so is only rational if possibilities exist to transport the produce to market quickly.

6.5 Planned Water Investments

In the decade from 1981–1990, 90 million US$ were supplied to Cape Verde in foreign aid for development of the water resources. The plans for the period 1993–2005 are ambitious and include a further 166 million US$, of which 57 million US$ were published as pledged or in action in 1993 by the INGRH (1993b:Table 17.03). Of the total sum: 79 percent are planned for actual investments; 5 percent for the rationalization of irrigation; and 74 percent for improving the drinking water supply and sanitation.

Table 6.8 summarizes planned investment by project, island, and source of water. The table shows a different profile of water investments depending on the island climate. Thus, on Sal, water investments are dominated by the desalination plant. On Fogo, the rainiest island, most investments are in surface water catchment. The two islands with large cities, namely Mindelo on Sao Vicente and Praia on Santiago, will both receive considerable investments in desalination plants, reflecting the large concentrations of population where insufficient water is available.

The table also shows that there will be virtually no public investments in the improvement of irrigation methods – of the small amount available to irrigation, half is used to dig wells (increase water supply) and half is used for "rationalization of water consumption, construction

Table 6.8. Planned public investments in water facilities, by type of expenditure and by island (in millions of 1993 Cape Verde Escudos). Calculated from INGRH, 1993.

Type of project	Total	Nat. proj.	Santo Antao	Sao Vic.	Sao Nic.	Sal	Boa Vista	Maio	San-tiago	Fogo	Brava
Planning	1572	235	87	48	51	11	149	57	784	99	50
Institutional	251	129	0	7	6	56	6	6	23	13	6
Management	797	0	83	197	134	0	0	64	248	0	70
Investment	8390	2086	462	1719	141	147	116	27	3049	621	24
(Desalination)	1617	0	0	840	0	133	84	0	560	0	0
(Ground water)	1890	0	60	0	83	0	25	14	1566	137	6
(Surface water)	1922	980	179	32	42	0	0	0	203	469	18
(Sanitation)	1733	0	224	840	0	0	0	0	669	0	0
(Fog)	980	980	0	0	0	0	0	0	0	0	0
(Solar)	126	126	0	0	0	0	0	0	0	0	0
(Education)	123	0	0	7	15	14	7	13	51	15	0
Irrigation	585	0	175	21	155	14	3	5	161	9	42
Total	11595	2450	807	1992	488	228	273	158	4265	742	192

Table 6.9. Total costs, estimated costs per cubic meter, and estimated capacity of planned water distribution projects. Calculated from INGRH (1993) data.

Project	Net costs in million 1993 Escudos	Net costs per m^3 annual capacity	Estimated capacity in million m^3	Total costs
Desalination plant at Sal	133	1209	.11	242
Desalination plant Boa Vista	84	1556	.054	153
Desalination plant in Praia	560	568	.986	1018
Ground water to Praia	504	920	.548	916
Rural ground water in Santiago	476	318	1.497	865
All other desalination	840	1106	.759	1527
All other ground water	911	609	1.496	1656
All surface water	1923	609	3.158	3496
Fog condensation	980	1106	.875	1120
Solar powered water supply	126	1106	.114	229
Total	6537		9.597	11222[a]

of reservoirs, increment of agriculture". The investments in more efficient irrigation methods, such as drip irrigation, are expected to come from the farmers themselves.

It is unsure how much capacity would increase if all the projects were completed. Increased capacity is only provided for five projects. With these five projects,[3] the an extra 3.2 million m^3 of water could be distributed annually at the cost of 25.1 million investments US$, net. The total costs of this water are assumed to be higher, namely, to include sanitation measures, planning, research, and management. The ratio of investment costs to total costs is equal to .55. With this ratio, the remaining investment funds, *and assuming the same costs per m as the five projects discussed above* another 8.42 million m of water would be added to the annual water distribution network. In total, using this calculation, 11.61 million m of water annually would be added to the piped water network by 2005.

Another calculation to estimate the amount of water to be distributed with these investments is to separate the costs per m^3 of desalinated water, ground water, surface water, and water obtained from fog condensation. The average investment costs per m annual capacity for

[3] Desalination on Sal providing 300 m^3/day at cost of 1.9 million US$; Desalination on Boavista providing 150 m^3/day at cost of 1.2 million US$; Desalination on Santiago providing 2700 m^3/day at cost of 8 million US$; Gravitational adduction of ground water on Santiago providing 1500 m^3/day at cost of 7.2 million US$; Rural water development on Santiago providing 4100 m^3/day at cost of 6.8 million US$.

Table 6.10. Reforestation in hectares from 1975–2000. Source: adapted from Courel and Chamard, 1992.

Reforestation in Cape Verde	1975	1976–81	1982–85	1986–90	1991–97	1998–2000
Semi-arid areas	(2200)	8489	1560	14000	16660	7650
High altitude areas	(730)	262	2880	2600	3200	1440
Total hectares planted	0	9751	14440	16600	19900	9090
Total forest end of period	2930	12751	27191	43791	63691	72781

desalinated water are 1106 Escudos (unweighted average of three known projects). The average per m^3 annual capacity for ground water are 609 Escudos. Fog condensation is estimated to have the same price as desalinated water, and surface water the same as ground water. These assumptions lead to 9.49 million m^3 capacity if all projects are finished. *Table 6.9* shows the results of this calculation by water source type.

6.6 Natural Vegetation and Reforestation

There are vague records from the beginning of the colonial time which state the islands are green. But the records are not good. Whatever their original state, the islands gradually became denuded.

Botanical studies indicate that the original climax flora on Cape Verde probably made it greener than it is today. It did not consist of woods in our sense. In the lower areas there was Palm or dune vegetation. In the low-altitude inland areas a vegetation reminiscent of the African Savannah; and in the higher areas, a vegetation society of dense bush growing up to 2 or 3 meters high. Some of this natural vegetation remains today. It varies in density and in color from dark green to silvery.

This natural flora and fauna is, as always, richer than the cultivation by man. However, the natural environment on Cape Verde is very delicate. Once the climax vegetation was destroyed, it did not re-establish itself. In Central-Europe, an indigenous forest will reestablish itself after 200 years. The tropical rain forest does not re-establish itself because all the minerals are in the plants and once the plants are gone, its minerals are gone. On Cape Verde, the minerals are stored in the ground but the balance is so delicate that land left to itself does not re-climax in visible time for humans.

However, trees are important for humans, especially in dry climates, because they counter desertification. They stop erosion of the top-soil, which is a problem on the steep islands of Cape Verde during the torrential rains. They capture the rain-fall and hold the soil moist, while allowing more of the rain to percolate into the ground water system. Underneath their foliage, grasses can grow for livestock. The trees can also be used to provide fruits for humans, wood for fuel, as well as other things.

On Cape Verde, a major reforestation effort has been underway since independence. The reforestation is done mostly in the dry Savannah-like areas of the islands (Courel & Chamard, 1992). By 1990, 35 thousand hectare had been reforested in semi-arid areas and 10 thousand in high, semi-humid areas. It does *not* compete with (irrigated or dry) agriculture. A further 30 thousand hectare are planned by the year 2000. This is shown in *Table 6.10.*

The main species of trees planted are Eucalyptus, Acacia, and Prosopis, and recently, the Purgeira nut tree. The Purgeira used to be widespread on the islands and the oil from its nuts were once the archipelagos major export crop. From the point of view of a biologist, the choice of trees could have been better, either by choosing local varieties (e.g., African Acacia instead of Chilean) or by avoiding trees which use all of the given water in their vicinity (e.g., Eucalyptus). The indigenous Dragon tree, which can turn into a rather majestic thing and is very drought resistant, was originally not planted because it grows slowly, and has no usable fruits. Now, it is also being planted as a national symbol.

The reforestation effort has been successful, particularly compared with other Sahel countries. The labor for the reforestation comes from the so-called FAIMO program discussed in chapter 5. It appears (verbal information from farmer) that some villages, such as Santa Ana on Santiago, located in a reforested rock-desert on Santiago live almost completely from reforestation work.

From reports of reforestation efforts elsewhere in the Sahel (e.g., Rochette, 1989; Sylva, 1993) and a comparison with the Cape Verde situation, the author sees two differences which may account for part of Cape Verde's success:

1. The reforestation does not compete with land used for other crops. It appears that such competition has been a problem in other countries.
2. Reforestation is a main source of income and as such gains importance in the eyes of the reforesters. In other projects, reforestation is often a part-time, or unpaid extra activity.

6.7 Conclusions

This chapter discussed the supply, the use, and the costs of water on Cape Verde, as well as the reforestation effort.

Most of the water used is ground-water or desalinated water. The supply of ground water which is accessible on Cape Verde is only 7 percent of the total rainfall, and is equal to 44 million m^3. This was an average of 332 liters per person per day in 1990. 22 million of this water are used for irrigation. A further 2 million m^3 are used for household consumption, industry and services. The plans to increase the water supply are estimated to increase the water distribution capacity for non-irrigation purposes by 9–11 million m^3 by 2003. This remains within the limits of the available water on Cape Verde. Costs of increasing the water supply are high – 12 percent of total investment from 1980–1989.

The present average per capita household consumption of water is estimated to be 22 liters per day, compared to 121 liters per person per day in Mauritius 1989. The commercial use of water per unit output are found in an estimation procedure using Mauritius unit water consumption as a standard. It is estimated that unit consumption on Cape Verde is equal to that on Mauritius, except in the service sector. The relatively low total commercial water use on Cape Verde is because the economy is dominated by sectors which use little water – namely, services.

The water use per hectare of irrigated land could be halved. The costs of installing an efficient irrigation system are only profitable if a higher value per hectare can be expected, and if that produce has a market.

The reforestation effort on Cape Verde has been successful. Two reasons for this could be that reforestation does not compete with land used for other crops and that reforestation is a main source of income and as such gains importance in the eyes of the reforesters.

Chapter 7

Alternative Ways to Look at Population, Development and Environment

This section summarizes the history of Cape Verde briefly, before turning to a discussion of qualitative and quantitative models that have been used in the past to analyze the relation of population, human activity, and the natural environment, and their relevance to this study.

The preceding Chapters 2–6 describe the history, population, social factors, economy and the environment of Cape Verde. The history of Cape Verde started in the 1460s and was influenced from the beginning by the dry, irregular climate which, with existing technologies and the social structures resulted in a poor colony. It was also influenced by its location, which made it an attractive slave-trading depot in the its first centuries of colonization, and subsequently invited foreign whalers to its waters. Contact with the whalers initiated a tradition of emigration. Emigration in turn, was the incentive for the beginning of a drive for formal education in order to acquire the skills necessary to obtain permission to go to receiving countries.

The dry climate caused regular crop failure and famines that decimated up to 30 percent of the population in a few years. It was also, however, apparently inconducive to the spread of many diseases that caused epidemics elsewhere, so that in between famines natural population growth was up to 2.5 percent annually in the last century. Thus, in Chapter 3 the hypothesis was given that a large part of the high life expectancy which was achieved in the second half of this century at very low levels of income was simply by providing adequate food to the population. Together with basic health provision the supply of food initiated a sustained period of population growth from 1948 lasting until the present time, tempered by emigration in the 1970s.

The rural population growth did not result in equal increases in agricultural production. Rather, it appears that the country has become increasingly dependent on food imports. Population in rural areas turned to employment in the public construction works program and urban migration. In the urban areas, economic activities in commerce, government services, private construction, and to a much lesser extent, manufacturing, increased. The labor force participation rate of women – 40 percent of them single with children and/or heading a household – is high at 45 percent.

Education of the population increased continually in this century, particularly after independence in 1974. Among young cohorts there is almost total literacy today in 1995. Secondary education is following the increase of primary education. The fertility level of women with secondary education was 2.6 children in 1990, whereas the fertility of illiterate women and women with primary education was above 6. With the 1990 distribution of education, this translated into an overall fertility rate of over 5 children per woman. With low mortality, this means continued high population growth.

The real income growth of the country was higher than population growth from 1974–1990. Until 1984 this was buoyed by increasing real foreign income transfers. Since that time, the real value of foreign transfers has decreased. but total income continued to grow.

The main environmental shortage in the country is water. During the 1980s, 12 percent of total investment was in the water sector – almost all of this for distribution. This income was not used for or is taken away from other investment or private consumption. The water which is used for human activity is ground water, of which 44 million cubic meters are available in dry periods. 25 million cubic meters are used for irrigation. The advantage of ground water is that it is available year-round, as opposed to, e.g., non-perennial rivers.

The chapters which described this show the particular Cape Verdean dynamic interplay between: population growth, size, and location; the social and economic activities; and the vagaries of weather and needs for water (read – the natural environment). In other countries and regions this dynamic interplay exists in ways particular to the area, but also in ways which are general.

These particularities and generalities have been analyzed previous studies, which created conceptual and mathematical models to clarify them. In this chapter, a selected number of approaches are described and their relevance to Cape Verde and the Cape Verdean's situation to them, evaluated.

The first approach described is a summary of an early, unresolved, discussion of population growth, per capita wealth and social development, with a limited food supply assuming fixed natural resources. This discussion occurred in the late 18th–early 19th century in Europe. Two main proponents were Malthus (1798) and Condorcet (1976, reprint). Malthus claimed that the population would grow until its density was so high that only a subsistence could be gained from agriculture. Condorcet claimed that population growth would stop due to voluntary fertility control. This is discussed in Section 7.1.

In the 19th century, it became apparent that the population of Europe overcame population growth through technological innovations and birth control. At higher stages of development, population growth stagnated.

This observation led to the theory of the demographic transition, first formulated by Notestein (1940). Parallel and related to the demographic transition an economic transition was described by Clark (1939) and Fischer (1940). These are discussed in Section 7.2.

The discussion on population growth, development and the environment regained new relevance in the 1950s when the populations in developing countries began to increase at high rates.

Coale and Hoover (1958) published a study on India in which they presented a model to analyze the interaction between population growth, education expenditures, and potential for economic growth. They also included resource constraints in their analysis. This is discussed in Section 7.3.

Of the above authors, only Condorcet explicitly considers that population growth and - pressure may advance development. The hypothesis that population pressure and crowding would actually lead a given population to seek solutions that would advance its development, and further, that a certain population density was necessary for certain types of social and economic advance, was put forward in different forms and disciplines by, e.g., Boserup (1981), Jacobs (1968), Lewis (1957) and McNeill (1991). This is discussed in Section 7.4.

These approaches have in common that they consider the effect of human activity on a limited but fixed resource supply. They do not, or hardly consider that human activity could degrade and decrease the supply of resources. Environmental degradation was included in two sets of models, global and local, which are based on the systems dynamics approach.

The global models, published by Forrester (1971) and Meadows *et al.* (1972) included population growth, economic output based on human and natural capital, technology of production, and degradation of natural capital. A large population size would degrade the natural resources that sustain it and this would eventually lead to a crisis. These models considered the world as a (homogeneous) point, and were criticized among others on the grounds that the estimates of interactions between their variables could not be empirically tested on this global level.

This was not true for the local models on the Sahel (Picardi, 1976) and Kivu (Wils *et al.*, 1976) in Africa. These models were based on the same systems dynamics as the global models, but their areas were heterogeneous, their variables and problems were small scale and measurable. These models specifically considered soil-erosion as a non-reversible phenomenon of environmental degradation following increased human agricultural activity (particularly on fragile, marginal lands). The systems dynamics models are discussed in Sections 7.5 and 7.6.

Concurrently with the systems dynamics models, a series of case studies by a different groups was done, called the BACHUE models. These models considered population, employment, and economic activity absent of environmental constraints. The BACHUE models were complex in terms of numbers of economic and social equations and variables, compared to the above models and are discussed in Section 7.7.

A recent approach was initiated by Lutz (1994) and is called the population–development–environment (PDE) approach. It was used for the case study of Mauritius to which this study is a sequel. The basic PDE approach is that the population with different social characteristics, the economy with government policy, and the environment are modeled separately in modules. The PDE approach is similar in parts, to the model developed by Coale and Hoover, and the BACHUE approach. It places more emphasis on the environment than these two approaches and this makes it more similar to the Condorcet/Malthus model and the systems dynamics models' focus. In this case study, as in Mauritius, the concentration has been on fixed resource constraints rather than on resource degradation resulting from human activity. Later case studies using PDE could include resource degradation, however. The PDE approach also includes the possibility that population pressure is resolved by innovative technology and social advance. The PDE model is described in Chapter 8.

A different selection of models is discussed in Chapter 3 of the Mauritius PDE-book, by Sanderson (1994a).

7.1 The Original Argument – Population Growth and Fixed Resources Lead to Adaptation or to Malnutrition: Condorcet and Malthus

Condorcet (1976, reprint) and Malthus (1798) considered a world of fixed size and a growing population. Initially, the population would cultivate lands and generate a surplus. This surplus could be used for consumption. Higher levels of consumption would lead to better health in the population, and to lower mortality. Unless fertility were checked, lower mortality would usher in population growth. The growing population would move onto and cultivate more land, until the only land left was of too poor quality to be cultivated. According to Condorcet, the population would react to its initial situation of surplus and population growth. There would be productivity increases, better possibilities of food conservation, reduction of waste, and higher education (particularly of women), which would collectively contribute to a reduced birth rate (*op cit.* Sen, 1994). The ultimate equilibrium would be a population of stable size at a high standard of economic and social well-being.

Malthus, in answer to Condorcet, proposed a different future namely that the population would not change its behavior and would maintain a high fertility level. The ensuing larger population (and perhaps lower average yields on more marginal lands) would lead to ever less food per capita, and through increasing malnutrition, mortality rates would creep up until they reached the level where they neutralized population increases from high fertility. The ultimate equilibrium would be a poor, malnourished population of a stable size. Later, Malthus gave more credence to the possibility that "people could, by their restraint, avoid the hardship that seemed inevitable in the first Essay" (Keyfitz, 1991:6).

It is obvious from subsequent history, that in industrialized countries and some developing countries, Condorcet's predictions were correct and Malthus was wrong. The discussion on the effect of population growth in fact was silent for some time. Galbraith (1979) explains why concern with population growth dropped out of economic theory:

In time, it became evident that in the higher stages of economic development people would, with great reliability, limit their numbers and that scientific and technological advance would enable people to maximize sexual enjoyment while minimizing the procreative result.

Concern over population growth than ceased to be economic in any decisive sense. It survived residually as a problem of space and environment. [Galbraith, 1980:45]

7.1.1 Condorcet, Malthus, and Cape Verde

Condorcet was correct in Europe, North America and a number of other countries. However, some countries were (and are) following a Malthusian path. Until 1948, it would appear that Cape Verde was a case of Malthusian equilibrium. There was a population largely in poverty and rough population size equilibrium. There would be population growth in the inter-famine years, but this was regularly set back by crop failure on the (largely marginal) lands of the archipelago.

Since that time, the country has overcome this limit, but initially not by the advances proposed by Condorcet. Cape Verde imported food from outside to overcome its environmental constraints. The social factors which contributed to this – emigration and foreign aid – alter the model proposed by these 18th century authors. Their model was a closed system, whereas that of Cape Verde is essentially open. The openness of the system and an elastic food supply allowed the country a window of time and surplus (which was necessary for advances) to embark on the education proposed by Condorcet. Large reductions in fertility, and large increases in productivity (agricultural or otherwise) are yet to follow, but not unlikely.

In conclusion, the international situation of Cape Verde significantly alters the results proposed by the conceptual model of fixed land resources and population used by Condorcet and Malthus. It shows that, e.g., that a country can be in Malthusian equilibrium, and, through input from outside, be nudged out of that equilibrium and given the chance to move to a different state.

7.2 Population in Transition: Notestein, Fischer, and Clark

The observation of the fertility declines following development and mortality declines led to the theory of demographic transition, which was formulated in its basic form by Frank Notestein (1940). According to the theory, once development sets in, mortality declines and population growth ensues. As development continues fertility declines. It declines because, the role of the family is taken over by larger units in society – schools, factories, institutes, health centers. For the family, having many children becomes less important, children become more expensive as they go through formal education, and new aspirations come into play which reduce the desired number of children (*op cit.* Freedman, 1979:63–64). There is consensus that there are social changes associated with declining fertility. It is not obvious which changes, nor to what extent they must prevail before a fertility decline begins.

Related to the demographic transition a number of (sub-) transitions can be described, which can be called the epidemiological, the education, the economic, and the density transitions.

The epidemiological transition concerns mortality. In the initial phase, deaths are dominated by infant mortality, infectious and deprivation diseases. Death is common at all ages, particularly in young children. Following hygienic and health improvements as well as medical advances, these causes of death are greatly diminished. This concurs with the mortality decline phase of the demographic transition. As people die at young ages much less frequently, the average life expectancy increases. In the second phase of the epidemiological transition, deaths which are characteristic of old-age dominate mortality. These are chronic, degenerative diseases such as cardio-vascular diseases, cancer, cirrhosis of the liver.

The educational transition begins with the situation where most people in the population are illiterate. Through various initiatives, private or public, education increases, first primary, then secondary and higher. In the final stage of this transition, almost all of the adult population is literate and large proportions have secondary or tertiary education. Once this stage is reached it has stability because the literate and well-educated adults form a pool of teachers for the following generations, who then also receive an education and can be subsequent teachers.

An important part of the change which drives the demographic transition is economic development. This also occurs as a transition one can read out of Clark (1939) and Fischer (1940), from an economy dominated by agricultural employment, to one where industry rises, and in the final phase, the advent of service employment at the cost of industrial and agricultural employment. The reason this transition occurs is described thus:

> Clark (1940) and Fischer (1939) argued that as a country's per capita grows, the decline in the relative demand for agricultural goods, along with rising agricultural productivity, causes the relative employment in agriculture to fall. At the same time, an increasing relative demand for manufactured goods causes the percentage of labor engaged in the sector to rise. In later stages of development, productivity increases in manufacturing, along with accelerated demand for services, cause the relative employment in manufacturing to fall in favor of services. [Pandit and Casetti, 1989:331]

Concurrent with the economic transition is a density transition from a largely rural population to one where the majority of the population is urban. This transition is a reaction to decreasing employment possibilities as agricultural productivity rises and increasing job openings in the essentially urban sectors of industry and services.

7.2.1 Population, Transition, and Cape Verde

The transitions are useful as guides for the direction of change socio-demographic change if countries develop, and for the direction of broad economic changes. The important question is whether these transitions, which have occurred as described in OECD and a number of other countries, are relevant in general to developing countries today and to Cape Verde in particular.

The epidemiological, education and the density transitions on Cape Verde are evident, and the country may be entering the third phase of the demographic transition with declining fertility. There are at least two reasons to believe however, that Cape Verde's economic change may not be the classic economic transition.

One is that the growth of services in Cape Verde preceded industrialization. Cape Verde experienced mostly growth in the service sectors commerce, transportation, government, and tourism, and very little industrial growth. It is theoretically possible to imagine an economic future for the country which is based on a further expansion of these sectors. Industry in this future would not develop into a major sector.

Another is that agricultural productivity and output have barely increased in the past twenty years. The growing (non-agricultural) population is supported by food from outside. It is possible that a dual economy develops with a large, traditional agricultural sector next to a modern service and industry sector. As long as there is population growth which provides workers for the growing industry and services and cheap food imports there could be no, or little wage or income competition between the agricultural sector and the industry and services. Then, there would be no imperative and less reward for the agricultural system to become more productive. The agricultural system would not "need" to become productive in order to supply surplus food and workers for industry and services. The final stage would be one with large service and industrial employment but with a large portion of the labor force remaining in agriculture.

7.3 Population Growth and Social Investment Hinder Economic Growth: Coale and Hoover

In the 1950s, what Galbraith called the "residual problem" of population reasserted itself as the populations of developing countries embarked on a period of rapid population growth. Following the historical experience of Europe and North America it is plausible that an observer could complacently view this population growth with the observation that development and the demographic transition would soon come and the population size would stabilize. One of the questions was whether this observer would be correct, or whether, on the contrary, "[p]opulation growth can hinder the development that would slow population growth" (Keyfitz, 1991). This is one of the central questions in the study published by Coale and Hoover (1958).

The situation considered by Coale and Hoover in India was an essentially closed system in which agricultural expansion was possible. Thus, resource constraints were not the main focus of their analysis. Instead, they considered that a population growing quickly has a higher proportion of young people than a population growing more slowly, all else being equal, and that this youth requires investments in nourishment, and, particularly, education, while not contributing to production. They developed a simulation model, with which they calculated two population scenarios – a high and a low population – from 1956–2011, and the resulting output.

In the high population scenario, large numbers of children would, in their model, increase family consumption and by consequence, reduce family savings. Lower savings would lead to lower material investment (in buildings, machines, infrastructure). Moreover, government spending on education, and taxation to pay for it, would be higher with larger numbers of children, further narrowing the trade-off space for consumption and savings/material investment.

In Coale and Hoover's model, education is considered an investment, thus, it complements material investment, rather than compete with it. However, the maturation of material investment is immediate (i.e. it can immediately be used for productive purposes), whereas the maturation of investment in education takes 10–20 years. In a situation of population growth, the maturation of education is consistently "lagging behind" population growth.

In this model, capital (material and education) and labor determine output. The high population scenario provides more labor than the low population scenario, but, due to the lower capital resulting from the mechanisms described above, ultimate output increase per capita is slower in the high population scenario. Population growth, they concluded, has a negative effect on per capita output.

Coale and Hoover also considered environmental ("natural resources" in their terminology) constraints. They concluded that until 1986 increases in agricultural output would be able to keep up with the numbers of people in their high population scenario (which is, in fact, what has been historically observed since their publication). After that, marginal investments necessary to further increase agricultural output would rise, and trigger a mechanism similar to that of high education investments on output, but stronger. The result of the high population scenario would be an ultimately *smaller* output pie to be divided over more people.

7.3.1 Coale and Hoover and Cape Verde

Much of Coale and Hoover's analysis of India is relevant to Cape Verde. Their representation of education as a capital investment in India fits to Cape Verde. In the limited economic system of Cape Verde it is also sensible to assume that education expenditures compete with other kinds of investments, which are to be paid out of the same pool of savings and taxes. It can also compete with private consumption, for example if consumers react to higher taxes to pay for education, by partially decreasing consumption as well as savings.

The conclusions that Coale and Hoover find from their calculations on the effect of limited natural resources are very similar to the ones found in the scenarios of Mauritius and for Cape Verde in Chapter 9 of this study.

The results found by Coale and Hoover then, have been validated. Can anything be added?

On Cape Verde, the costs of environmental investments are an immediate problem, rather than one of the distant future. A model of Cape Verde would bring these investments more to the fore. Second, in small, open economies such as Cape Verde, the influences of external forces – foreign income, exports, imports – are prime determinants of the country's output. Coale and Hoover's analysis with a Cobb-Douglas labor/capital output function would need to be substituted or adapted to account for such forces. Further, it would be interesting to find whether the openness of an economy alters the generality of the results found for the closed Indian system.

The model that Coale and Hoover calculated was simple, constrained by the computer technology of the period. Since 1958, advances in computer technology allow more complex modeling, and, perhaps more importantly, the speed and ease of computation allow a large number of scenarios and trial runs to be produced. A larger number of scenarios allows the user to test more hypotheses. It also allows a completely different *manner* of making scenarios, which is discussed in Chapter 9.

7.4 Population Growth Fosters Adaptation and Social Advance: Boserup, McNeill, and Others

Population growth and increasing density can also be viewed as the motors to social and technological change. Such a view is proposed explicitly by, e.g., Boserup (1981), Carneiro (1970), Cohen (1984), and McNeill (1991) and related ideas are proposed by, e.g., Jacobs (1969) and Lewis (1954). In these views, population pressure, increasing density and population surplus in certain pockets of the economy cause tensions in the existing mode of production and social organization. These tensions are resolved by a series of adaptations. Basically, in the conceptual model proposed by Boserup and others, greater pressure on land, causes an intensification of agriculture, e.g., through the spread of irrigation schemes. Such intensification may be facilitated by the ability to build infrastructure such as large-scale irrigation projects with a larger population and labor force. The agricultural intensification, infrastructure increase, cause increases in agricultural productivity. This higher agricultural output can be used to feed people not employed in agricultural activities. Thus, urbanization is possible. Urban growth ensues. In the urban areas, new ideas can develop more quickly than in sparse population due to cross-fertilization of ideas, the exigencies of organizing larger numbers of people, and the possibility to specialize due to large, concentrated markets. Boserup summarizes thus:

> We have seen in previous chapters that there were two important linkages between population density and technological levels in ancient societies. The first was between population size and the amount and quality of infrastructure. A large population could undertake large-scale investments in canals, roads, and irrigation facilities, which would not be feasible for a smaller population. Therefore, increase in density of population by natural increase or by immigration was a precondition for use of more advanced technologies. The second link was that between population size and natural resources. When population density increased within a region, the amount of natural resources, both per head and sometimes in absolute amounts, was reduced. Therefore, technologies such as extensive subsistence systems could no longer be used when population density exceeded a certain level. Thus technological change was needed either to economize the use of natural resources, or to make it possible to use substitutes for them.
>
> ... These improvements in infrastructure made large-scale urbanization possible ... Cross fertilization of ideas and systematic specialized training were possible because the elite now could live together in the urban center instead of being scattered in villages as formerly.
>
> ... The need to organize the urban economies and to keep accounts led to some of the most important inventions in the history of humanity, those of written language and numbers. [Boserup, 1981:76–77]

A similar process was proposed by Jacobs (1969) with the initial productivity increase arising in cities and the initial population change a concentration rather than growth. The concentration of people, she argues – in villages, then towns, then cities – arose out of trading. Such concentration was always a fertile situation for cross-fertilization of ideas and products. The wealth of ideas springing from concentrations of people included improvement of agricultural cultivation methods. The application of these better methods allowed further population increases and concentrations.

In Lewis' (1954) model of industrialization, a surplus population in the rural areas, arising from population growth, is necessary input for the growth of industry.

7.4.1 Boserup and Cape Verde

To what extent is the conceptual model of advance due to population pressure applicable to developing countries presently and to Cape Verde in particular? The answer to this question is provided by Boserup and McNeill themselves.

Concerning the application of more intense agricultural methods in reaction to population growth, Boserup writes:

> The acceleration of population growth in the Third World revived old Malthusian fears. We have seen, however, that in many earlier period, the response to population growth was intensification of land use, and this experience was repeated in recent decades. In step with the increase of world population, intensive systems of agriculture replaced extensive systems in larger and larger parts of the world. [Boserup, 1981: 200]

However, Boserup also points out that the present population increases are much higher than the historical increases of the societies which she analyzed. Therefore:

> It is important to note that the multiplication of population in the ancient world bore no resemblance to the recent explosive increases. Mortality was high, and estimates for long-term rates of natural growth point to annual growth rates of 0.1–0.2 percent in areas with growing population. ... Thus, ancient population had ample time to adapt to population increase by developments or imports of new systems of food supply and by improvement of the quality of inputs. [Boserup, 1981:43]

She concludes her work with the following paragraph:

> Thus, at the second stage of the demographic transition, when the number of children per family is no longer increasing but the number of young adults in the country continues to increase rapidly, the most crucial factor is likely to be the ability of national governments to improve the utilization of the resources of labor, land, and capital by means of suitable economic policies. ... But the leading elites in [Europe and Japan] had much more time to adapt to population changes, because such changes were much less rapid than those in Third World today. Moreover, in most of the countries which recently became independent, the ruling class is handicapped by insufficient experience ... Under these circumstances, they could hardly be expected to be able to solve the problems of rapid population growth and avoid economic and political difficulties. [Boserup, 1981:211]

Other authors, e.g., McNeill, also issue words of caution in the application of their analyses of historical successful adaptation to population growth to other situations:

> We are liable to think that the successful responses in the core areas of Europe were somehow normal ... But is was a norm to which others aspired, not one which they achieved, save in rare and exceptional cases. The delicate balance between rural and urban productivity and concerted public action that sustained Europe's primacy in the world was difficult to replicate ... [McNeill, 1990:19]

In conclusion, these authors write that population growth causes tensions that require solution. There are recognizable patterns in the ways in which this tension is solved, such as intensification of agriculture, urbanization, and social reorganization. If the resolution is successful, advance has occurred. However, success is not guaranteed.

On Cape Verde, the urbanization predicted by these authors is occurring. The role of the government, e.g., as a major employer and a provider of services, is also changing. The balance of these changes with agricultural productivity increases is hardly present. This is likely to make the Cape Verde system less robust than a system with productive agriculture to support population growth. It is possible that foreign income substituted successfully for agricultural productivity increases on Cape Verde. If so, this would be an interesting addition to the conclusions of this general conceptual model.

7.5 Population in a Fragile, Degradable Environment: Global

The three conceptual models discussed above do not or, hardly consider the effect that population activities could have on changing the environment. It is assumed that the activity reaches fixed limits, or that productivity increases. The stability of the environmental background gives these models stability.

The assumed stability of the environment is incorrect, argue, e.g., Daly (1977), Ehrlich and Ehrlich (1991), Forrester (1971), Meadows et.al. (1972) and others. The environment is changed by human intervention, which can upset ecological systems and initiate problems such as: erosion, eutrofication, ozone-holes, global warming. When these occur, the environmental resources are degraded and actually diminished. One argument of these authors is that increasing population causes an intensification of resource use or movement to marginal lands (in concurrence with the authors above). This intensification or new settlement can cause the resource base to diminish. By the same argument of the effects of population pressure, this causes further intensification and further moves to more marginal lands. The effect is a vicious circle once this chain of events is set in motion, at the end of which the large population can no longer be sustained and a crisis ensues in which large death tolls reduce the population until it is small enough that the reduced resource base can sustain it. The predictions of this group of authors are thus more dire even, that those originally made by Malthus.

Forrester organized this conceptual model into a computer simulation model. He says of his book and model:

> This book examines some of the forces that will become barriers when growth goes too far. It examines the changes that can arise to stop exponential growth. It begins to examine the transition from a world of growth to a world in equilibrium. [Forrester, 1971:5]

The approach used by these researchers, "systems dynamics" was developed at MIT to look at the principles governing changes and trends of variables in a system, which could be a social system, an economic, an industry.

> This book [subject] is devoted to the theory, principles, and behavior of feed back systems. It is in the positive feedback form of system structure that one finds the forces of growth. It is in the negative feedback, or goal-seeking, structure of systems that one finds the causes of fluctuation and instability. [Forrester, 1971:7]

Forrester developed a model which he called the World Model, and this model was adapted by Meadows *et al.* (1972) into the World3 model. This model showed that at given rates of population increase, and assumed rates of the natural capital stock decrease, there will be a crash point where population size overwhelms the Earth's capacity to regenerate its natural resources or where pollution abatement costs overwhelm the economy's ability to produce goods for non-pollution abatement consumption (symbolized by food). The authors developed a number of different scenarios with different assumed rates of population growth, pollution abatement efficiency increase rates; effects of crowding; high agricultural productivity increases; lower investment; stricter resource use controls. All scenarios with continued growth – including those with increased efficiency and productivity – ultimately resulted in a collapse. Only the scenarios in which population growth and population activity per capita were stabilized resulted in a sustained level of production and quality of life.

7.6 Population in a Fragile, Degradable Environment: Local

Parallel to the world models, at least two regional computer simulation models of developing regions in the Forrester/Meadows tradition, where parameters could be specified, were made.

One was a Sahel study (Picardi, 1974), the other of the Kivu region in Rwanda (Wils *et al.*, 1976). The Sahel study is described, e.g., in Barney *et al.* (1991), and Sanderson (1994). This section describes the Kivu model.

The Kivu model describes the feedback loops between population growth, malnutrition, production, and soil erosion. The analysis of the region,

> ... permitted the creation of a conceptual model which represents the various mechanisms which, according to us and the information we have, can play a major role in the exacerbation or the alleviation of malnutrition in the Kivu region.[1] [Wils *et al.*, 1976:63]

The model considers a world of increasing population in which limited agricultural extension is possible by migration to marginal lands and soil-erosion control.

Population growth is determined by the age-structure and the presence of malnutrition, whose main effect is to reduce fertility by increasing the age at marriage, the lactation period, and fecundity, i.e., involuntary birth-control. At very high levels of malnutrition, mortality increases. In the model, the effects of voluntary fertility control are not considered because the cultural factors in Rwanda made a decrease in desired fertility unlikely in the near future – considering the TFR of 8.5 in 1992 this turns out to have been a realistic assumption in 1976.

> One of the conclusions is that, given the limits of possible hypotheses, notably that high values on fecundity would remain, there is no other mechanism to balance the birth rate and the death rate other than a decrease of nutrition.[2] [Wils *et al.*, 1976:93]

High population pressure in the model leads to reduced periods of fallow on the land, which causes soil erosion, an unsuccessful intensification of agriculture. In the base scenario this mechanism starts the vicious cycle of population pressure, intensification of agriculture, resource degradation, greater population pressure on the remaining resources.

The model considers two mechanisms to react to this population pressure. The one is migration to an empty area of land with somewhat less fertile soils – extensification of agriculture to marginal soils. The other is technical reaction in the form of introducing counter-erosion or soil fertility measures – successful intensification of agriculture. The third, most successful adaptation the model suggests is large-scale migration from the over-populated fertile area to the empty, less-fertile area and anti-erosion measures first in the fertile, then the less fertile area. Migration from the over-populated fertile area to the empty less-fertile area gives the system the necessary time to implement anti-erosion projects.

Ultimately, without any mechanism to stop population growth other than malnutrition, even the scenario of migration and soil-erosion control measures cannot do more than postpone the onset of the vicious cycle that would lead to such high levels of malnutrition that population growth stops. Considering the different reactions to population pressure however, shows how large the "window of time" is to implement more radical and ultimately sustainable changes.

7.6.1 Kivu and Cape Verde

The Kivu model shows that imposing a constraint on fertility decrease forces the modeler to consider solutions to population pressure other than fertility reduction. This is a world in between that of Boserup and Malthus. In this, it provides valuable lessons for the case of Cape Verde which is also faced with pressure from increasing population which is likely to persist for some decades to come. One such lesson is that migration opens a window of time in the system, but does not ultimately solve the internal mechanism causing tension to develop.

[1] Author's translation. Original text "Le tout nous a permis de creer un modèle conceptuel representant les divers mechanisms qui, selon nous et selon les données dont nous disposons, peuvent jouer un rôle majeur dans l'aggrevation ou dans l'allègement de la malnutrition dans la region du Kivu".

[2] Original French: "Une des conclusions qui s'impose est que, dans les limites des hypothèses admises, notamment le maintien des hautes valeurs de fecondité, il n'est d'autre mechanisme pour equilibrer natalité et mortalité que la diminution de la nutrition."

The model of Kivu considers a system that is wholly agricultural and with no social progress which could result, e.g., from education, nor changes of life-style which could result, e.g., from urbanization. In effect, the system of Kivu is one in which the basic mechanism of growth is not altered. This leads to an inevitable crash, regardless of efficiency increases or other adaptations, as in the World models and the Picardi model.

In Cape Verde, adaptations in growth behavior are likely, and can be realistically included in the model. The dynamics of education and urbanization as shown in the analysis of Cape Verde are relevant processes which influence, e.g., fertility behavior and economic activity. The model of Cape Verde should also consider effects of population and environment on development in a system which is open enough to theoretically solve many constraints, e.g., food production, through imports. In fact, the model of Cape Verde shows that even in such an open system population and environmental constraints affect development.

7.7 Population and Employment: BACHUE

Concurrent with the systems dynamics models another set of models was developed based on case studies. These were the BACHUE models, which were designed to analyze the interactions between population, employment, and income distribution.

The BACHUE models are national demographic-economic models which were developed at the ILO, and originally funded by the UNFPA. The first BACHUE model of the Philippines (Rodgers *et al.*, 1978)

> is about the relationships between population, employment and income distribution, and about how these relationships can be integrated into development planning. ... The ... work has several objectives. It is intended firstly to contribute to the understanding of relationships between population, employment and the distribution of income; secondly to demonstrate the role of one form of analysis – large scale simulation models ... [Rodgers *et al.*, 1978:1]

The core of the model is an input–output model for the economy, with exogenous exports and government spending driven by population and exogenously determined scenarios. "Final demand is adjusted to equal production, i.e., no general equilibrium solution is produced through the medium of prices" (p. 31). The population is divided into 5 year age groups, sex, urban-rural residence, and education. Migration, fertility and mortality are endogenous variables, determined by socio-economic determinants: incomes, income distribution, labor force participation rate of women, and education. The model is concerned with income distribution, which is the result of sectoral economic growth – and hence employment – and intra-sectoral distribution of types of work.

The BACHUE model does not include environmental factors. The authors juxtapose what they call the Malthusian view which argues that

> Continuing population growth ... is a threat to human welfare. The basic reason is because the resources of the earth are finite, and exponential population growth is bound to exhaust them sooner or later. [Rodgers *et al.*, 1978:2]

to the opposite view which is

> also widely accepted. The question of limited resources is sometimes seen as a problem so distant that we need not explicitly consider it now – it has even been argued that given conceivable levels of agricultural progress, the earth could support a population hundreds of times its present size. Other writers have pointed to the possible exploitation of non-earth resources. [Rodgers *et al.*, 1978:2]

7.7.1 BACHUE and Cape Verde

The BACHUE model was used to compare the outcome of various strategies and assumptions about the economic and social variables such as, e.g., urban-rural migration, income distribution, export, employment policy (Rodgers *et al.*, 1978:355–383). Four different "population scenarios" are considered with identical population size but different population distribution and different relations of population to output (pp. 383–394).

In conclusion, BACHUE was used to answer social and economic questions within a framework which relegated to the margins two of the dynamics which are of central concern in this study: namely the effects of different population futures on development, and the effects of environmental constraints or -benefits. It thus answers completely different questions than this study, and the emphasis in the simulation model is on different variables than the one this study is concerned with.

However, the use of generally accepted models for the projection of population – namely the cohort component method – and for the projection of the economy – an input-output model – make parts of the specifications of the BACHUE model and the PDE-model used for Cape Verde similar in form.

7.8 Conclusion

This chapter discussed seven existing conceptual models which include population, development and the environment, or population and development, each of which provides valuable insights and suggests fruitful directions of investigation. None of the models was found to fit exactly to the questions raised by this study and in the previous study on Mauritius. Therefore, a new model was developed, which is called the population–development–environment (PDE) model.

This model is described in the next chapter.

Chapter 8

The PDE-Cape Verde Model

8.1 General Population–Development–Environment (PDE) Model Description

The modeling method used in this study was developed in an earlier case study of Mauritius (Lutz, 1994), and is called the Population–Development–Environment (PDE) approach. The PDE approach is different from the above described models in a couple of important aspects.

It is a comprehensive approach, like those described in the previous chapter. It differs from these models because it separates the population, the development, and the environment, and uses an own, specifically developed module for each of these sectors. The modules used are standard to the respective disciplines – demography for the population module; economics for the development module, and ecology or other for the environmental modules. The simulation model approach here takes these modules as they are, connected via a selected number of key variables, and runs the three modules in parallel.

This approach is used because the dynamics of population change, of economic change, and of the environment are different from each other. To try to catch the different dynamics with one type of model would demand a greater simplification than is necessary with this approach.

By using standard models and combining them at least one part of the scenario results will be recognizable and understandable to researchers in different disciplines. Perhaps this recognition will create the willingness to understand or accept other parts of the model that are less familiar.

Although there are cumulative effects which are similar to positive feedback loops used in system dynamics, the PDE approach is not a system dynamic one because it contains no negative feedback loops.

The lack of negative feedback loops means that tensions which arise from running the modules parallel to each other are not resolved. For example, the population scenario may project a large number of people in the year x, while the environment module projects no water investments, which leads to impossibly low levels of water available per capita. These and similar tensions remain in the scenario, unresolved by the model itself. However, when there is such a tension, the *model user must resolve it* by changing the scenario assumptions – for example, to lower the population projections, or to change the scenario to include water investments.

There are two reasons for doing this. The first is that the model is transparent to the user. There are no solutions to problems which are taken care of without the user knowing about them. The second is that there are different possible solutions to tensions encountered in the real world. A water shortage could be met by increasing supply, but also by increasing efficiency of water use, or by emigrating out of the water-poor area. The model leaves it up to the user to experiment with different possible solutions.

There are a number of disadvantages to this approach. For the scenario maker, it means that making each scenario is very time consuming, because resolving the tensions requires a lot of hand-tuning and iterations. It also leaves the possibility that the scenario maker overlooks a tension and leaves it in the scenario, producing results that are actually impossible. For a

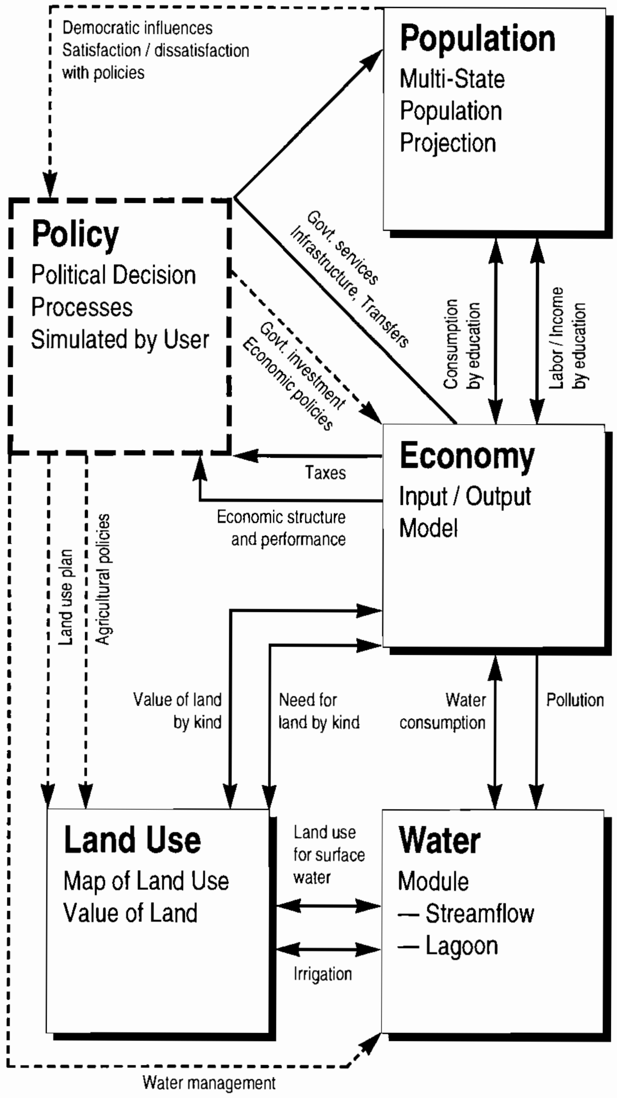

Figure 3. The basic structure of the Mauritius PDE-model.

Figure 8.1. Basic PDE-model structure. Copyright: IIASA, 1994.

further discussion of this subject, see, e.g., Wils and Prinz (1994), Prinz and Wils (1994), Holm *et al.* (1993).

The model is made in *modular form*, that is, the description of the population on the one hand and the economy with the environment on the other are separate entities. In principle, one can make scenarios of alternative futures of the population alone. *Figure 8.1* shows the basic model structure. The Cape Verde model includes a population module, a development module which includes the economy and government policy, and an environmental module which includes water and agriculture.

The modules are linked to each other. Population provides labor to the economy and the economy provides jobs. Population also provides the number of consumers among whom income is distributed and drives subsistence demand.

The economic module is linked to the population via labor and consumption. It is linked to the water module via demand and provision of water. The agricultural module provides the output of the agricultural sector to the economic module. Government demand is influenced by the size and age-structure of the population, and by the scenarios for investment in water distribution capital. This demand translates into the government sector of the economy in the economic module.

The supply sides of the water and the land modules are independent in that the supply of water and agricultural output is calculated without input from the other modules. However, the demand for water and for food derives from the size of the population and the extent of economic activity.

The *population module* is taken from existing multi-state population methods. The population is divided into sex, age, and so-called socio-economic "state" groups. The model includes changes in fertility, mortality, and external migration (people entering and leaving the population) and transition rates between states. The age groups are usually one or five-year classes. The socio-economic states can be varied according to the exigencies of the case before the student. One can chose for example to divide the population by education, regional residence, labor force participation rates, religion, or other characteristics of interest. In the case of Cape Verde, the population is divided into three education classes – in school, with at least primary and at most secondary. The basic reason for the division between primary and secondary is the differential fertility of women with at most primary and those with at least secondary education. It is also divided into rural and urban states. It is possible to transfer between some socio-economic states (such as, e.g., moving from urban to rural areas) but not others (e.g., race, or educational characteristics once school is finished).

The *economic module* is a macro-economic accounting system of the macro-economic type extended to a multi-sector economy represented by an input-output table. It includes an inverted production function which specifies the relation between labor, capital and output per sector. This type of model is good for scenarios because it is flexible and transparent – one can try out policies, different export paths etc. and see the effects. It is good for a combination with environmental analysis because the national product is given by production sector (each of which has different environmental coefficients) and bad for an analysis of the substitution effects caused by prices.

The module used here is an adaptation and improvement from an earlier version used for Mauritius. It calculates economic product depending on export, government demand, and domestic agricultural product. Investments and consumption are endogenous. The module calculates labor demand based on the technology development chosen, capital and the education of the labor force. Its output is economic information – national product, consumption, investment, capital and other variables –, and information on employment, natural resource use, and natural resource supply.

Government policy enters the economic module in the form of public investments in education and health for the population, as well as infrastructure measures which in this model are limited to water investments.

The Cape Verde *environment module* includes agriculture and water. The availability of water for irrigation and all other purposes is calculated based on the durable capital which is available for the distribution of water and the maximum amount of water provided by Nature plus desalinated water. The natural supply of freshwater is largely located in the ground water although there are some perennial rivers or river beds that can be dammed. Investments in water-supply capital such as dams, wells, desalination plants can increase the annual supply of fresh water available to the economy and the population, with consideration of partial maximum limits imposed by annual rainfall. The water-supply capital has a given lifetime after which it has depreciated and needs to be replaced. It also has maintenance costs.

The agricultural output is calculated based on the land used for rain-fed agriculture and the exogenous output per unit of land, and on the amount of water available for irrigation times the efficiency of irrigated water use. The efficiency of irrigation depends on the capital being used, and the model calculates the type and costs of irrigation materials. This module could be extended by considering the type of agricultural methods used, market conditions, water distribution systems, ownership, education and sex of the farmers. This would provide more dynamic agricultural module.

The population and the economic modules are, in essence, complex *extended matrices*. The calculation is done as a sequence of equations as a matter of preference, although formally, there is no difference. The notation of extended matrices rather than sequential matrix calculation for a demo-economic model is for example used by Luptacik (1990).

The population module is calculated first, independent of the assumptions in the rest of the model. Second, the supply side of the environmental modules, water and agriculture are calculated. The economic and government module, and demand for water, are calculated third.

The matrix equations are all linear and concern one period, a snap-shot of an instant in the time series. Inter-period changes can be non-linear, such as exponential export growth, or an exponential fertility decrease; step-wise, non-patterned increments in water-supply investments; or user determined choice between levels of technology efficiency.

The model is a semi-general equilibrium model, in other words, some of the supplies and demands are not in equilibrium at the end of the calculation. For example, the model calculates water demand and water supply separately and it can happen that the supply and demand are not in balance. This attribute of the model raises the hairs on the heads of those who like models where prices regulate supply and demand. In a general equilibrium model, if the potential demand for water was higher than the demand, the price would go up, and the demand would decrease until it was equal to supply. The other variable which is not balanced is labor supply and demand.

8.2 The Population Module

The population module is used to project the population by economic states. It is a so-called cohort component model which takes the age structure of the population into account.

The cohort component model was originally developed by Whelpton (1936) and formalized by Leslie (1945, both cited in Lutz, 1994). It is extensively and well-described in, e.g., Keyfitz 1977 or Wunsch and Termote 1978. The model uses the vector of the age-and sex-specific population size and the so-called Leslie matrix with probabilities of dying plus migrating along the diagonal and age-specific fertility rates along the first row for a population with n age-groups.

What the cohort projection does is the following. It takes the age-pyramid of the population in the starting year with x age groups of n years width. It requires the age-specific mortality, net-migration and fertility rates. The mortality and net migration rates are each applied to the relevant age category of the pyramid for the length of one period. The projection periods have to be n years long. At the end of the period, each age-group in the pyramid has shifted up one age group and has been reduced or increased by attrition through mortality and net-addition through migration. The projection calculates births with the age-specific annual fertility rates of women. The fertility rates are multiplied by the number of women in each category and by n years. These births are summed together, distributed to males and females according to a boy:girl birth ratio which is known. Mortality and migration rates are applied to this youngest age-group of the next period.

The mortality, fertility and migration rates usually apply to one year. But often, the projection intervals are five years. The problem arises that the actual probability of dying, of having birth, or of migrating are different than the annual rates (strictly speaking, this problem applies to one year intervals with annual rates given also: people are dying, migrating and having birth on a time continuum and not on an annual step basis). For mortality, the model calculates probabilities that arise considering the annual attrition from the population through death. The probability of dying in the age-group x is:

$$q(x) = \frac{nM(x)}{1 + \frac{n}{2}M(x)} \tag{8.1}$$

From one period to the next, the population in each age-group moves up one age-group and a part of the group dies. On average, each member of an age-group spends one half of an interval between periods in the younger age group, and one half of the interval in the older age-group, subject also, to the different probabilities of dying in the different age groups. To incorporate this effect, the population in each age group in each period is given by the product of the population in the previous age group in the previous period and the average effect of the differential mortality in each age-group. This is given by the equation:

$$P_{x,t} = P_{x,t}\frac{l_x + l_{x+1}}{l_{x-1} + l_x} \tag{8.2}$$

where $P_{x,t}$ is the population in age x at time t, and l_x is the proportion of the population that would survive to exact age x under prevailing mortality conditions or, $1 - q$.

The fertility rates consider the mortality of the women in the child-bearing age-groups during the period, the transition of women from one age-group to the next during the period. It is assumed that babies are born half-way through the period, when on average, half of the women who will die in the period have died and half have made the transition to the next age group. Thus, the number of births borne by the women who are in age group x at the beginning of the interval is:

$$B = \frac{5}{2}\sum_{\substack{\text{fertile}\\\text{ages}}} F_{x,t} + F_{x+1,t} * P_{x,t} \tag{8.3}$$

where P_x is the population of women in age x at the beginning of the interval, and F_x is the annual fertility rate.

At the end of the period, a number of the babies born has died. It is assumed that the babies are born mid-way through the period, and subject to half of the probability of dying in that period. Thus:

$$P_{0-4,1} = sB_{t-1} \times (1 - \frac{5}{4}Q_{0-4,t-1}) \tag{8.4}$$

where s is the sex ratio of births.

The net migration should be assumed to occur mid-way through the period on average. Alternatively, one can assume absolute numbers of migrants. Again, these should exit or enter mid-way through the period. In this model, the simplifying assumption is made that migration occurs at the beginning of the period.

Further elaboration can be found in the literature.

One can imagine a system where the out-migration from the population is the in-migration for another population. And one can imagine extending this to more than two populations. These populations are projected simultaneously and parallel to each other. The mathematics for this *multistate population projection* were worked out by Rogers and Willekens (1986) at IIASA. Originally, these models were used for actual regional states. However, it was soon recognized that states could also be socio-economic states which could be treated as if they were geographical. Lutz and Prinz (1993) state:

> ... The traditional cohort component method of population projection uses only the variables age and sex. To include additional dimensions – such as education, and economic activity – the so-called multi-state population projection is used. This method is used to simultaneously forecast populations in multiple regions that interact with each other, i.e., in addition to giving birth, dying, people are considered to migrate from one state to another at any age. *Originally used to be applied to different geographical regions, this method can be applied to different population groups living in the same region* (authors italics), be it marital status groups, or education groups, urban/rural populations. The people in one group can transition into another group. Characteristics that cannot be changed, such as ethnic belonging, need to be projected with separate parallel models. [*op cit.*, Lutz and Prinz, 1993]

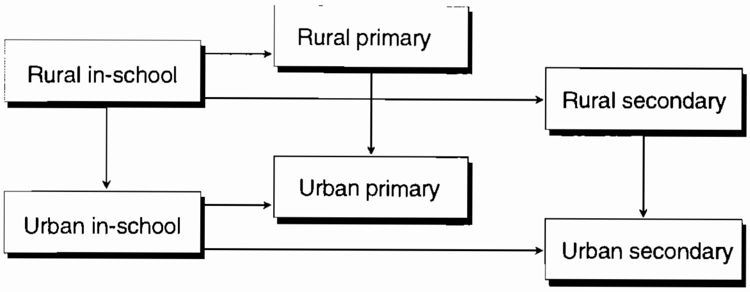

Figure 8.2. Socio-economic transitions in the multi-state PDE-Cape Verde model.

The mathematics of the model is such that it considers the intra-period aspect of transition from one state to the next, intra-period mortality and fertility. In the model used here, a simpler construct is devised. All transitions occur at the end of the period.

The Cape Verde module considers two regional states, urban and rural and three educational states: in-school; out of school with a maximum of primary education; and out of school a minimum of secondary education. The choice of these characteristics follows from the analysis of Chapters 3 and 4. Concerning the rural/urban choice: running throughout the analysis is the idea of the economic transition from a rural based agricultural economy to an urban dominated industrial and service economy. Cape Verde appears to be making this transition – which does not necessarily apply to all countries of the world – with implications for the labor available in agricultural, industrial and service jobs, access to health care, demand for housing, and other differences. The education split is motivated on two grounds. The population in school is necessary to calculate the education expenditure of the government. The model keeps track of the amount of education expenditures what proportions of each cohort receive and this determines the productivity of the differences between cohorts and within cohorts. The split between primary and secondary is motivated by a different observation, namely that the fertility of women with no and with primary education on Cape Verde was virtually the same in 1990, and the fertility of women with secondary and tertiary education was virtually identical.

Figure 8.2 shows the structure of the Cape Verde population module.

8.3 The Economic Module

The input-output model has been successfully used to calculate gross output and income generated by sector based on a sector vector of final demand and the intermediate input matrix. The matrices have been extended to simultaneously calculate emission levels and pollution abatement levels necessary to satisfy minimum environmental standards by Leontief, 1970. Endogenous consumption and investment levels in extended input-output models have been incorporated by, e.g., Miller and Blair (1981), Rhee and Miranowski (1983).

The disadvantage of the models is that they tend to be static, although linear dynamics have been incorporated. They are also basically demand driven. However, economic output is determined by the *supply* of factors of production as much as by the demand for final goods. General equilibrium models calculate income based on the supply of the factors of production, notably labor, capital, and/or energy inputs and dynamic productivity measures. The general-equilibrium model incorporates non-linear marginal substitution or -productivity levels of the factors of production. Long-term futures research models of the general equilibrium form are published in, e.g., Mesarovic and Pestel, Dayal (1981), and Parikh (1981).

Input-output models are desegregated by sector, which makes them useful for short-term analysis, but more problematic for long-term future scenarios. The general-equilibrium model can be aggregated and often are. They can therefore identify the more global dynamics of the economy which are important in middle- to long-term futures research. Hybrid models, with general-equilibrium calculations and an input–output table are also used (Lee and Roland-Holst, 1993).

In this model, income by highly aggregated sectors is calculated with an input-output model, with endogenous consumption and investment levels. The employment of labor is calculated with an inverted Cobb–Douglas function, borrowed from general-equilibrium modeling. The agricultural output is calculated in an environmental module, and is wholly dependent on supply factors alone. This decision is motivated by the assumption that the model applies to economies with poor agricultural output, where output always falls short of (potential) domestic demand.

8.3.1 Economic equations

The gross domestic product of an economy with n sectors is the value added portion of gross output and can be written in input-output terms as follows:

$$Y = v(I - A)^{-1}F \tag{8.5}$$

where v is the n x n diagonal matrix with the elements $v_{i=j}$ reflecting the value added portion of gross output in the n sectors. The value added is the residual after intermediate products (domestic and imported) are subtracted from gross output; A is the n x n technical coefficients matrix; and F is the n final demand vector.

In the simplest input-output model, the final demand vector is given, but in extended models it is divided into an exogenous portion and a portion that is a function of income y:

$$F = E + f(Y) \tag{8.6}$$

8.3.2 Exogenous demand

In the PDE-Cape Verde model, the exogenous portion of final demand is: exports; social and infrastructure expenditures by the government; capital maintenance expenditures by the government; foreign investment transfers; foreign remittances; and subsistence demand from the population.

The sum of domestic exogenous demand is:

$$E = E_X + G + T + A^d + REM + C_o \tag{8.7}$$

where E_X is vector for export demand; G is the vector for government consumption demand; T is the vector for foreign investment transfers; A^d is the vector of amortization for domestic water investments; REM is the vector of remittances; and C_o is the vector of subsistence food demand.

Exports are determined exogenously by the user at absolute levels for each domestic sector in a column vector with n elements.

The social expenditures by the government are those arising from educational, health, and general needs of the population, and are determined by policy for per-capita outlays and age-distribution as educational and health expenditures are very age-dependent.

The infrastructure expenditures of the government arise from the construction of roads and buildings, communications installations, and environmental measures such as, e.g., anti-erosion walls, water reservoirs, treatment plants, etcetera. To a large extent these are investments are subsumed in the investment function – which separates public and private investments. However, there are maintenance costs for infrastructure which are included in government consumption. In the PDE-Cape Verde model, which concentrates on the distribution of scarce water, the government infrastructure costs are those used for maintaining the piped water supply.

Total government consumption expenditures are:

$$G = R_{gs}(s \cdot ed + h + gen)P + R_i m_w \tag{8.8}$$

where R_{gs} is the $n+m$ column vector showing the distribution of social government expenditure in n domestic sectors and m import sectors; P is the column vector of population with x five-year age groups; s is the x row vector with elements of school participation rate in age group x taken from the population module; ed is the diagonal matrix with x dimensions whole elements $e_{i=j}$ show per capita expenditure on education per pupil in age group x; h is a row vector with x elements showing per capital health expenditure in age-group x; gen is a row vector with x elements showing general per capita government outlays, usually identical for all age groups; R_{gi} is the $n+m$ vector of the infrastructure costs distribution; and m_w is the scalar of maintenance costs taken from the water module.

Cape Verde, and the earlier case study country, Mauritius, both received and receive large amounts of foreign investment transfers. The money going to Mauritius is private and destined for the export enterprises in the country (Hanoomanjee, 1994). The transfers to Cape Verde have, so far, been public transfers in the form of aid (see Chapter 5). Foreign transfers, private or public are an exogenous user-variable in this model. They are used for production or environmental capital, discussed in Section 8.3.6. The exogenous transfer demand is equal to:

$$T = Ri\ T_{sc} \tag{8.9}$$

where Ri is the $n+m$ vector of investment distribution; and T_{sc} is the scalar for foreign investment transfers.

Other foreign transfers are remittances from workers abroad which are assumed to be used by the families receiving them for private consumption:

$$REM = Rc\ REM_{sc} \tag{8.10}$$

where Rc is the $n+m$ vector of variable consumption distribution; and REM_{sc} is the scalar for foreign remittances.

The remittances are determined by the number of emigrants abroad – which is provided by the population module – and the remittances per emigrant:

$$REM_{sc} = rem\ EM\ e^{-5\delta} \tag{8.11}$$

where rem is remittances per emigrant; EM is the sum of net migrants from previous periods, with an annual death- or other attrition rate equal to δ (the return of migrants is included in the *net-* migration function of the population module).

Subsistence demand results from population size. As discussed in the previous chapter, an increasing population seeks to meet its needs either by expanding or by intensifying (agricultural) production. As shown in the case of Cape Verde, this population driven demand was not always met by domestic production, but often by imports. The model includes this in the following way:

1. There is population-driven subsistence demand, which is income-independent.
2. The local production of subsistence is limited by the maximum agricultural output possible with the then existing land, water and technology.
3. If subsistence demand is higher than maximum agricultural output, the remaining portion is imported.

Subsistence demand is equal to:

$$C_o = coP = agrmax + M_o \tag{8.12}$$

where c_o is the per capita subsistence demand in absolute value. In the PDE Cape Verde model it is equal to the average of "poor" and "ultra-poor" defined by the World Bank (1992). At this level, subsistence demand is equal to per capita agricultural demand in the 1988 input–output table used in the model; P is the total population; $agrmax$ is the maximum domestic agricultural output; and M_o is the food imported to satisfy subsistence demand.

The technical coefficients in the agriculture column of the input-output matrix are changed endogenously by the model so that gross output is equal to subsistence demand; domestic agricultural output is equal to *agrmax*; and the imports in are equal to M_o. This solution – changing the technical coefficients – is the only way out of the conundrums of putting a resource supply-side limitation (namely agricultural output) in a demand-side model.

8.3.3 Endogenous demand

Investments and private consumption are dependent on income, or $f(Y)$, following conventional macro-economic models (see, e.g., Dornbusch and Fischer, 1981, Mansfield, 1980, or more recent standard texts) and extending these to include the input-output matrix. Both of these variables, however, have an exogenous element in the PDE-Cape Verde model, namely: foreign transfers for investment; and subsistence consumption as well as remittances for consumption. Splitting consumption and investment into their exogenous and income-dependent portions, one obtains:

$$I = Ri\ T + A^d + Ri\ i\ Y \tag{8.13}$$

and

$$C = Rc\ REM + Co + Rc\ c\ Y \tag{8.14}$$

where i is the portion of income that is spent on domestic investment; and c is the portion of income that is spent on consumption on top of subsistence and remittance consumption.

Both i and c are found empirically for the period 1970–1990 by inserting the data for Ri, Rc, T, Y, REM, and C_o in the above formulae. They are exogenous variables for the future scenarios, which determine C and I depending on income.

Collecting all the demands into the national income function gives:

$$Y = vL(EX + G + Ri\ T + Rc\ REM + Co + Ri\ i\ Y + Rc\ c\ Y) \tag{8.15}$$

Collecting the expressions with Y on the left, and solving for Y:

$$Y = (I - vL(Ri\ i\ + Rc\ c))^{-1} vL(EX + G + Ri\ T + Rc\ REM + Co) \tag{8.16}$$

For further notation:

$$MCI = vL(Ri\ i + Rc\ c) \tag{8.17}$$

Income is positively related to E, exogenous demand. Therefore, the inverse, $(I - MCI)^{-1}$, must have all non-negative elements. A necessary and sufficient condition for this inverse matrix to be non-negative is that the absolute value of the largest eigenvalue of the matrix, *MCI*, the Perron-Frobenius eigenvalue, is between zero and one. A sufficient condition for the Perron-Frobenius eigenvalue to be less than one is that all of the columns in the matrix sum to less than one. Experiments showed that in the following cases this is true (a formal proof that it is always true in the input-output framework may be possible but is outside the scope of this study):

1. The product of the v and L matrices is a matrix with an eigenvalue less than one. When imports are a larger portion of gross output, $v_{i=j}$ is smaller. The larger the portion of intermediate inputs which is imported, the smaller the eigenvalue. In the special case when imports are zero, the eigenvalue is equal to one exactly. Negative imports are not considered in the model, so vL always has an eigenvalue less than one.

$$\left| \begin{matrix} 1 - \sum_{j=1,n} a_{1,j} - m_1 & 0 & 0 & 0 \\ 0 & 1 - \sum_{j=1,n} a_{2,j} - m_2 & 0 & 0 \\ 0 & 0 & \ldots & 0 \\ 0 & 0 & 0 & 1 - \sum_{j=1,n} a_{n,j} - m_n \end{matrix} \right| \left| \begin{matrix} 1 - a_{1,1} & -a_{2,1} & \ldots & -a_{n,1} \\ -a_{1,2} & 1 - a_{2,2} & \ldots & \ldots \\ \ldots & \ldots & \ldots & \ldots \\ -a_{1,n} & \ldots & \ldots & 1 - a_{n,n} \end{matrix} \right|^{-1} < 1 \tag{8.18}$$

2. The product of vL and $(Ri\ i + Rc\ c)$ is a matrix with a Perron–Frobenius eigenvalue of less than one. vL is less than one, as shows above; R_i and R_c are always less than one. However,

$i + c$ can be greater than one in countries with a very negative trade balance, in other words, countries which spend far more than they earn domestically, such as Cape Verde (the highest value in Cape Verde was 1.44 in 198x). If these values are not compensated, MCI can turn negative. In fact, there is one general, and one PDE-Cape Verde specific reason that it is highly unlikely for MCI to turn negative even with high i and c:

2a. In the case when $i + c > 1$, this indicates a negative trade balance or, very high imports. High imports are reflected either in a low vL (as discussed above) or in low domestic R_i and R_c (discussed in Wils, 1993). The higher the value of $i + c$, the more negative the trade balance.

2b. In the PDE-Cape Verde model, large portions of investment and consumption are determined exogenously, which reduces i and c substantially.

8.3.4 Imports and trade balance

Imports are the sum of the imports for all final demands, and the imports for intermediate goods,

$$M = FD_m + IG_m \tag{8.19}$$

where FD is the demand for final goods; and IG is the demand for intermediate goods.

In matrix terms:

$$M = [m_{fd}][E, C, I, G, C_o] + [m_{ig}][Y/v] \tag{8.20}$$

where m_{fd} is the mx 5 matrix with in each column the propensity of each type of final demand to import the m_ith good; m_{ig} is the mxn matrix with in each column the propensity of each output sector to import the m_ith intermediate good; and Y/v the n vector with income in each sector divided by the portion value added, or, gross output in each sector.

The trade balance is the difference between the sum of the imports vector and the exports vector:

$$TB = \sum E_x - \sum M \quad . \tag{8.21}$$

8.3.5 Investments, capital, and labor

The investments in each sector i are added to the existing depreciated capital in that sector in a conventional manner. It is assumed that investments mature in the relevant period.

Total investments are the sum of foreign transfers and domestic investments according to equation 8.13. The investments are distributed over only two sectors: the non-water sector, which is the sector that produces end-products, and the water (read: environmental) sector, which includes the infrastructure for the above-mentioned natural goods.

The investments in water are determined by the user's scenario for water projects (see Section 8.4), and are equal to I_w, which are partially paid for with foreign transfers and partially with domestic funds.

The non-water investments are equal to the remainder:

$$I_p = I - I_w \tag{8.22}$$

The value of capital in the non-water and water sectors is determined by the depreciated value of capital in the previous period (vintage capital) plus the investments in the respective period in each sector.

The depreciated vintage capital in each sector is:

$$V_{n,t} = V_{n,t-1} * e^{-5\delta} \tag{8.23}$$

where δ is the period depreciation rate, t is the designation of the period, and n designates water or private investments.

And the capital is:

$$K_n = I_n + V_{n,t-1} \tag{8.24}$$

The capital/output ratio, which indicates the capital intensity of production is shown in the model for the non-water sector only. The water sector is excluded. This means that investments in water (read: environment) do not contribute to the productivity of other sectors. If water (environment) is more capital intensive than the other sectors of the economy, this will tend to lower the average capital intensity and productivity of the non-water sector. If the water sector requires no investments, this raises the average productivity of the non-water sectors. However, not investing in water can cause difficulties, for example, water shortages.

The labor necessary for the production of calculated output Y in sector n is an inverted Cobb-Douglas function of Y_n and K_n. The Cobb-Douglas function related capital and labor available with technical coefficient to income:

$$Y = \alpha L^{\beta} K^{1-\beta} \quad . \tag{8.25}$$

Labor is solved as a function of income, capital and technology. The solution is a balance for capital, because all that is available is used, but there may be an imbalance for labor as the supply of labor does not affect the demand calculated here. By inverting the Cobb-Douglas function, the demand for labor is:

$$L_n = [Y_n/(\alpha K_{n\beta})]^{1/\beta} \quad . \tag{8.26}$$

The values for β in the production function are found heuristically in the historical years to provide the observed employment figures given assumptions about capital, capital intensity, and labor productivity.

Linear increases in α, technological progress and education expenditure, exponentially decrease the amount of labor required for a given output at a given level of capital.

8.3.6 Education of labor and labor productivity

One of the main arguments for increasing education (e.g., Schultz, 1979, Blaug, 1979) is that education increases labor productivity. In the previous PDE-Mauritius model, the productivity increases of education were approximated by "productive" weights attached to education levels primary, secondary and tertiary. This approach has the disadvantage that increases in educational expenditure within a certain level of schooling – for example, increasing the expenditure per pupil in primary school – had no effect on productivity, which is contrary to intuition. In order to include the fact that it is not years of schooling per se, but quality of schooling which determines productivity increases, the PDE-Cape Verde model calculates labor productivity based on the sum total of educational investments, or "education expenditure received". The present equation is a linear one – which means that each Escudos of education received adds as much to productivity. Undoubtedly, a logarithmic function would be better – to reflect the intuition that the greatest productivity increases are attained learning basic skills and the higher the education level, the more expensive it becomes and the less are the marginal social benefits (see, e.g., Todaro, 1981:305-8).

The relationship of educational expenditure received and productivity from educational expenditure, ε, is normalized to the starting year including the education distribution of workers in each sector in the starting year. Workers with primary education are given productivity equal to 1, those with secondary equal to 2. The productivity index for each sector is equal to:

$$\varepsilon_n = [(p_{n,0} + 2s_{n,0})/(p_{n,0} + s_{n,0})] \cdot (\mathit{Ted}_t/\mathit{Ted}_0) \tag{8.27}$$

where ε is the coefficient for productivity from educational expenditure in sector n; p_0 is the number of workers with primary education only in the starting year in sector n; s_0 is the workers with secondary education in the starting year in sector n; and *Ted* is the total education expenditure received by the whole population.

The educational expenditure which was received by each age group at each point in time is known from the equation on government educational expenditure shown above. This equation shows the per capita expenditure and the school participation rate in each age group. This gives the average per capita expenditure received by the whole age group in every time t. At the present time t, each member of sex s in age group x has received the following education expenditure, on average:

$$\begin{aligned} Ted_{s,x,t} &= s_{s,x,t} \times ed_{s,x,t} + ed_{s,x-1,t-1} \times ed_{s,x-1,t-1} + s_{s,x-2,t-2} \times \\ &\quad ed_{s,x-2,t-2} \cdots s_{s,x-x+1,t-x+1} \times ed_{s,x-x+1,t-x+1} \end{aligned} \quad (8.28)$$

These "education expenditures received" in each age group are converted to productivity coefficients for each age group, $\varepsilon_{s,x,t} = (Ted_{s,x,t}/Ted_0)$. The average educational productivity coefficient for the whole potential labor force is the weighted average of the productivity of each age group:

$$\varepsilon_t = \sum\sum \varepsilon_{s,x,t} NSP_{s,x,t}/NSP_t \quad (8.29)$$

where NSP is the non school population, taken from the population module.

Productivity of labor (directly, or indirectly via better capital) is improved by education, but also by technological progress. The changes in technology and their effect on productivity are given exogenously by the user. The total productivity coefficient is simply the product of the education productivity index and the technology productivity index.

$$\alpha = \tau \cdot \varepsilon \quad (8.30)$$

where α is the productivity coefficient from above; and τ is the exogenously assumed technological progress, and is equal to 1 in the starting year.

8.3.7 Consumption distribution

As income changes, the marginal propensities to consume various goods also change. One solution to reflect this in a model would be to attach income-elasticity to the various income goods. However, the determination of the elasticity remains a complex task which is beyond the capacity of the data available in almost all countries. A simpler solution is called for.

It was argued in the PDE-Mauritius study (Wils, 1994) that in moving from a very low income to a higher one the major change is in the propensity to spend income on food. This propensity decreases as income increases. To reflect this, private consumption is divided into subsistence consumption, which is wholly basic foodstuffs, and variable consumption, which is a fixed vector of consumption distribution including "luxury" food, housing, clothing, leisure goods, in short, all other private consumption. Variable consumption is only possible when income exceeds that necessary for subsistence consumption. The combination of these two types of consumption results in a changing distribution of consumption depending on income, through the different weights that the two fixed consumption vectors have in the proportion of income spent on each type.

The distribution of private consumption demand is then:

$$C_d = c_o P + R_c(Y_d - c_o P) \quad (8.31)$$

where C_d is the weighted vector of consumption distribution; and Y_d is disposable income after investments and government spending.

The advantage of this solution is over the one used in previous work is that the distribution of income does not matter, *as long as the whole population can satisfy at least substance consumption.* This is a much weaker condition that the ones that would attach to income-elasticity or income distribution which were older solutions. At the same time, it results in a dynamic change in private income distribution depending on income.

8.4 The Water Module

The water module of Cape Verde includes the supply and distribution of water. There exist on Cape Verde other aspects of the environment. There are natural resources, such as fish supply, solar and wind energy resources, or Pozellano earth. In some areas of the country there appears to be significant erosion as farmers crowd into more marginal and steeper lands, or as terraces are neglected. There is the reforestation effort on the islands, which increases the availability or a renewable energy resource for cooking, and which may increase percolation of rain water into the underground aquifer system, thereby increasing the annually renewable ground water supply. These environmental factors are not included due to constraints in the study, and because water appeared to be the most important environmental factor. In a more detailed study a number of factors which have been excluded here would need to be included.

The fresh water availability on Cape Verde is limited by two factors. One is the natural maximum of water available. This is the amount of water that is surface run-off and the amount of water that percolates into the ground water. The second is the human investments in the system, which channel the naturally available water towards human activities. These can be dams or reservoirs to catch surface runoff; or wells and pipes to tap ground water; or a number of other methods discussed in Chapter 6 on environment. Another human capital type of investments is desalination plants. These tap into a water resource that is unlimited compared to human water needs on Cape Verde – the ocean.

The water distribution system on Cape Verde can be basically divided into two branches: irrigation water for agricultural purposes, tapped from wells and reservoirs built for this purpose; and piped water which is used in human settlements for household and commercial purposes.

For every purpose, a part of the water is actually lost through use – either by being incorporated in products, or by evapo-transpiration, or by flowing out of the system into other regions or unusable (e.g., salt) water bodies. Another part of the water flows back into the system, and in principle can be re-used. More complex water models include this return flow into the system after use. It is not incorporated into the Cape Verde model, because in small island systems usually most of the water is lost into the ocean after having been used once. Re-cycling water however, could be an important technological investment on Cape Verde in the future that is not considered in the model.

The investments in the water distribution system on Cape Verde are from public funds, of which a part is paid by the government with domestic loans, and a part of which comes from abroad as a grant or a loan. On a macro-economic scale, the distinction is important because of the role of amortization payments, which the government has to finance through taxes or other income. Amortization payments for investments which are financed by domestic domestically flow back into the Cape Verde financial system. If the investment was financed by a foreign loan, then amortization payments leave the Cape Verde system. If the investment was a grant from abroad, there are no amortization payments.

In the water module, the user specifies whether the investments are domestic or foreign-funded. Thus, investments is equal to:

$$I_w = I_w^f + I_w^d \tag{8.32}$$

where f refers to foreign investments and d to domestic investments. All parts of the distribution system require maintenance, which is typically paid for and done domestically in the government consumption expenditures (equation 8.8).

The water availability and distribution system is modeled on a *project basis*. Each investment in the water system on Cape Verde is designated as a project. Each project is characterized by: the source of water; the use of the water; the rate of water loss; financing; interest rate; amortization rate; and life-time of project. It is assumed that the projects function at full capacity until the end of their life-time and then become wholly defunct. In reality, the maintenance costs may increase as a project becomes older, until the costs are so high that the project is abandoned, but the module does not include this more complex dynamic. In the initial period, an estimate is made of the existing water projects according to the above characteristics. Each new period, the user can add new water projects in a scenario, and attach the characteristics as desired. Each period, the module finds the projects which are still in their active life-time, and adds the new projects. It also finds the projects for which loans are still being repaid.

Thus, the capacity to distribute water is the sum of the capacity of all available projects:

$$WS = \sum_{p=1}^{n} W_{l,ti}^{p} \quad s.t.\ t - ti < l \tag{8.33}$$

where WS is the water supply; W is the capacity to distribute; l is the lifetime of the project; ti is the period of investment, t is the present period p is the designation of the project; and n is the number of projects.

The module sums up the projects according to different combinations of the characteristics. All the water projects using surface water are summed up and compared to the available surface water. All the water projects using ground water are summed up and compared to the available ground water. All the projects for irrigation are summed up and this information is used to calculate the amount of agricultural produce from irrigated land (see Section 8.5). All the piped water projects are summed up and compared to demand for piped water from household and commercial users.

The amortizations on all projects are calculated and paid to the domestic market or transferred abroad. The domestic amortization flows into the pool of funds available for domestic investment. Thus, the model has built in that domestic investments in water postpone, but do not replace investments in the private sector. However, in order to pay for the amortization, the government has to raise taxes, which reduces the propensity to consume (lower GDP) or the propensity to save (lower investments). The foreign amortization flows out of the country and out of the system, and thus has the typical effect of a foreign loan, which is to be an infusion into the economy at the time the loan is given, and a hemorrhage of economic product during the repayment period.

The government pays for both foreign and domestic amortization, and these costs have to be covered by taxes or by foreign transfers. Thus, the total government expenditure is:

$$G = G_s + G_m + \sum A_f + \sum A_d \tag{8.34}$$

and amortization is equal to:

$$A_t^{d/f} = \sum_{t=0,a} I_{l,ti}^{d/f} \times \frac{r}{(1 - (1 + r)^{-a}} \quad s, t, t - ti < a \tag{8.35}$$

where A is total amortization, either domestic or foreign; r is the annual interest rate charged on the loan; a is the amortization period; ti is the period of initial investment; and t is the present period.

8.5 The Agriculture Module

The agricultural activities on Cape Verde consist of two different systems. One is the rain-fed agriculture the other irrigated agriculture.

Rain-fed agriculture was the backbone of the country's grain-supply until imports supplemented them. The crops are maize and beans. In some areas, such as the higher altitudes on the north-east sides of Santo Antao, Fogo, and Santiago, there is a crop in most years (more than seven out of ten). But maize and beans are also sown on areas which can expect a harvest in only four out of ten years, depending on the rain-fall. The crop is largely dependent on the amount of land that is sown, given average expected rain-fall. The rain-fed agricultural output is simply:

$$agrmax^{rf} = L^{rf} * O^{rf} \tag{8.36}$$

or, maximum value of rain-fed agricultural output is the product of the amount of land planted and the expected value of output per hectare.

The harvest on irrigated land is determined mainly by the availability of water and by the efficiency of the irrigation method. Traditionally, water was available at large intervals, fields were flooded, and the water left to sicker in. A much more efficient use of water is with the, e.g., drip irrigation method, where water is stored in a tank at the side of the field, and dispensed onto the land through perforated rubber tubes as the plants require it.

The costs of investment in the more efficient irrigation method and the resulting productivity and water use are calculated in the model. The user specifies the amount of investments in the irrigation method for the agricultural sector, I^a. Dividing the investments by the investment costs per cubic meter of water to be used efficiently, \$, provides the cubic meters of water which will be channeled through the efficient method.

$$W^{ie} = I^a/\$ \tag{8.37}$$

where W^{ie} is the amount of water used efficiently. The proportion of water used efficiently, w, is the ratio of W^{ie} to total water for irrigation, W^i. The extent of efficiency is given by Φ, which is the ratio of output per cubic meter of water with the efficient method to the output per cubic meter of water with the traditional method.

The total irrigated output is the product of the water available, the output per cubic meter of water under traditional irrigation methods, and an indicator of the extent of the use of the more efficient drip-irrigation methods:

$$agrmax^i = W^i * O^i * [1 - (\Phi - 1)w] \tag{8.38}$$

where $agrmax^i$ is the value of agricultural output from irrigation; W^i is the water capacity in cubic meters for irrigating, taken from the water module above; O^i is the value of agricultural output per cubic meter of water using traditional irrigation methods; Φ is the measure of efficiency of the new irrigation method i.e. how much more value can be expected per cubic meter of water using more efficient irrigation; and w is the proportion of irrigation water which is being applied in the new irrigation method.

If there is no efficient irrigation capacity, the value of agricultural output is equal to the traditional method. If all water is funneled through the efficient irrigation method, then the value of agricultural output increases by the relative efficiency of new irrigation over traditional irrigation.

The payments for the installation of drip-irrigation are calculated in Escudos per cubic meter of water. Like in the water module, each investment has a life-time and is fully functional until exactly the end of that life-time, and the module keeps track of the capacity still in use. The payments for the investments are treated as investments on the domestic market, and, as they are relatively small are paid in the period of investment.

The environmental module is calculated before the economic module, as there are no automatic feed-backs from the environment to the economic module. There are a number of results which are used as input into the economic module, namely:

A^d, A^f, I^d and I^f for water distribution, I^i for efficient irrigation methods, and $agrmax$.

The economic module calculates water demand for piped water and compares this to the supply.

This model is used to make scenarios for Cape Verde which are discussed in the next chapter.

Chapter 9

Scenarios for Cape Verde

9.1 Model Validation – The Historical Scenario

In order to validate the model, an historical scenario is made. This exercise tests the dynamics and the accounting systems which have been put into the model, as well as the data and the estimations. The historical scenario should reproduce the changes which actually occurred in the observation period.

The process is an iterative one, with small changes to the model, small changes to variable estimations, and testing of different data sources, until the model results reproduce the historical path to a large and satisfactory degree.

A number of the variables which are exogenous to the model are provided by the data. These are *used* as input to the model. Other exogenous data are not provided by the data and thus have to be *estimated.* The model results which are provided with these estimations are *checked* against actual historical data. For such checks, actual historical data have to be available. There are also model results for which no historical data exist and these results have to be heuristically *judged* on their reasonability. Many of these data, estimations, and results have been discussed in the preceding Chapters 2–6.

Table 9.1 provides a list of the variables which are available to be used, those which have to be estimated, result variables which can be checked against data, and result variables which have to be judged.

The historical period 1970–1990 is used because it includes the beginning of an accelerated pace of change in the important indicators education, non-agricultural production, urbanization, fertility, use of efficient agriculture techniques, government expenditure, level of investment. It is also long enough that population changes are sufficiently large that the model results can be checked against historical change. This period also includes the change from the colonial period to the independent, modern one; it includes the long drought during which the country changed so much; and it includes some of the newest changes such as manufacturing increases and irrigated agriculture increases. The period begins with the 1970 population census and ends with the 1990 population census.

One cannot expect the historical scenario to reproduce the actual historical path exactly. Most obviously, this is because the model is a simplification of a much more complex reality, and the results reflect only a selection of the influences that shape the paths of historical events. Ideally, the historical scenario will uncover trends which are clear and reasonable, which can be continued into the future for the future scenarios. Also ideally, the historical scenario will uncover events which have a long time momentum, because this momentum carries over into the future and allows some certainty about future events.

9.1.1 Population – historical scenario

The population is divided into sex and 17 five-year age groups, and into urban and rural population, subdivided into three education categories: in-school, primary education or less, secondary education or more. Altogether, this gives ($2 \times 17 \times 2 \times 3 =$) 204 population categories to be estimated correctly. The census data of 1970 provide the original values of the 204 categories,

Table 9.1. List of exogenous variables, and endogenous (result) variables, categorized by data availability in literature.

Exogenous variables		Endogenous (result) variables	
Data available, *used*	No data, *estimated*	Data available, results *checked*	No data, results *judged*
Fertility rate by age	Fertility by education and location		
Mortality by age	Mortality by education and location	Population by age, education, and location, 1970 and 1990	
Total migration	Migration by age, education and location Domestic transition rates		
Exports			
Remittances			
Public transfers			
Government expenditure on health, education, general services	Expenditure on health, education, general services by age		
Employed by sector	Employed by education and sector Vintage capital in starting year Depreciation rate of capital		Capital value in scenario years except starting year
Total water investment 1980–1990	Water investment by year Amortization costs of water investments	Piped water capacity, 1990	Piped water capacity, other years
Hectare rain-fed agriculture	Productivity rain-fed agriculture per hectare	Value of rain-fed agricultural output	
Water used for irrigated agriculture	Productivity irrigated agriculture per cubic meter water Investment in drip irrigation	Value of irrigated agricultural output	

and the 1990 census provides the ultimate values. In between these two end-periods, values for the movement of the population in between all the categories, and into (births), and out of (emigration and death) the population by category have to be inserted. The data to do this are, in no case, available, as *Table 9.1* shows.

For example, the differential fertility rates for urban, rural, educated and less educated women are not known; neither are the age-specific net-migration rates; nor the domestic transition rates from rural to urban areas.

It is therefore hardly surprising that the historical population scenario *does not exactly reflect* actual historical population movement. However, it does so reasonably well. In general, the population estimated by the model is about 10 percent larger than the 1990 census population in almost all population sub-groups. The *relative* size of the main population sub-groups is the same in the historical scenario as in the census data. *Table 9.2* shows the 1990 model estimations for the large population groups – urban, rural, in-school, primary, and secondary – compared to the 1990 census results, for both sexes and by sex.

Table 9.2. The estimated and census population in 1990, by five large population groups and sex. Source: model calculations and DGE, 1993.

		Total	Urban	Rural	"In-school"[a]	Primary, not in school[a]	Secondary, not in school[a]
Both sexes	Model	368274	168373	199901	177311	177781	13182
	Census	341491	156761	184730	157995	170219	13277
Men	Model	172744	77315	95429	88481	76772	7491
	Census	161494	74811	86683	79316	74304	7874
Women	Model	195530	91058	1044472	88830	101009	5691
	Census	179997	81950	98047	78679	95915	5403

[a] "In-school" population equal all children under 10 years and those older than 10 years in school; "primary" and "secondary" refer to non-school population only. Calculations based on in-school population by age and school-type and total population by completed level of instruction and age as provided by the DGE, 1993.

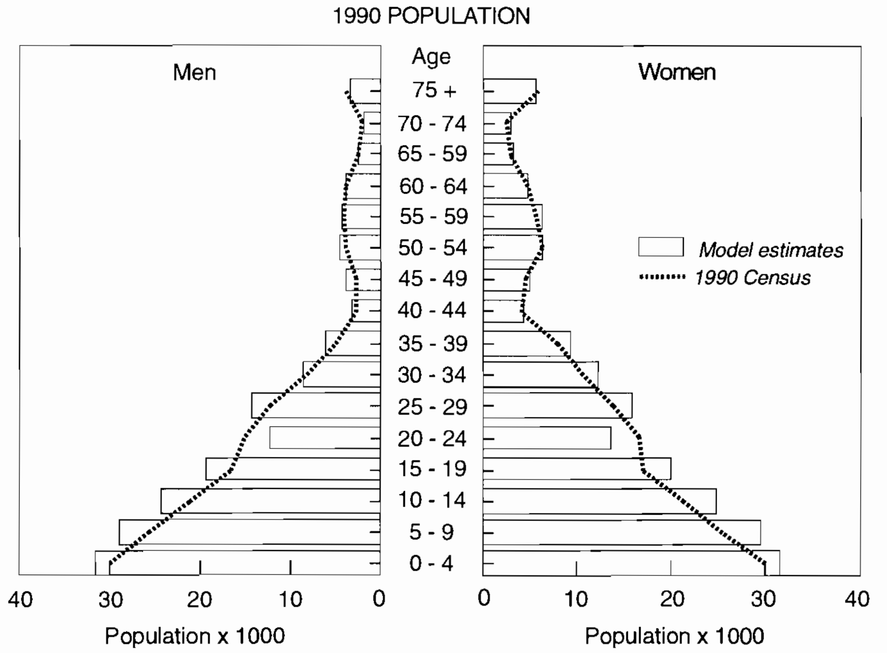

Figure 9.1. Population age pyramid for 1990, according to the model estimations (bars) and 1990 census (lines). Source: model calculations, and DGE, 1993.

Figure 9.1 shows the age pyramid of the historical scenario and 1990 census. The age pyramids are nearly identical, except in the age-group 25–29 where the model estimates a smaller group that was counted in the census.[1]

In order to obtain the 1990 census results more exactly, three alternatives are open:

1. Decrease fertility even further below data indications (the estimate used is 18 percent lower than the data indicate in 1970).
2. Increase net-migration by 80–90 percent of data indications, which leads to a correct number of births but too few young adults in 1990.
3. decrease the life expectancy increase in the period 1970–1990 considerably.

None of these alternatives is desirable unless well-motivated.

On the other hand, the model results reflect those of the UN 1990 population estimation. The total estimated population is 368 thousand in 1990, compared to 363 thousand estimated by the United Nations.

[1]This is because the age-distribution of net-migration is held constant in the period 1970–1990, as discussed in Chapter 2. In reality, there appears to have been an age-shift in the migrant group.

Table 9.3. Macro-economic variables for the historical period 1970–1990 on Cape Verde. Sources: Model calculations, IIASA, 1995 and World Bank, 1992.

Year		Variable consump.	Consump.	Govern. expend.	Invest-ments	Exports	Imports	Gross domestic product
1970	WB	3007	8495	730	2102	2679	6218	8377
	model	2525	8194	909	1904	2606	6263	7319
1975		1756	7301	1518	1947	2046	3750	8513
		1431	7266	1517	1703	2504	5859	7115
1980		7579	13493	2153	6070	3340	9168	14006
		6991	13279	2159	5889	2941	11084	13129
1985		9895	16470	4659	7935	4691	12731	19567
		10237	17248	4527	7816	4812	15641	18598
1990		10655	17855	5606	10584	4130	13850	22249
		10299	17962	5640	9627	5410	18137	20366

Because the relative size of the groups is the same as the census data, and the total population size is the same as that of one major information source, the historical scenario results are taken to be satisfactory.

9.1.2 Macro-economic indicators

The economic module is used to calculate variable consumption per capita, gross national product, and the accompanying macro-economic variables, total private consumption, variable consumption, government (non-investment) expenditure, total investments, exports and imports. Two other major variables are private transfers from abroad – remittances – and transfers for investments. Historical time-series are available for all of these indicators, published by the Cape Verde DGE (1989, 1991), and by the World Bank (1993).

Deviations between the model calculations and the data are to be expected. First, the data are annual values, whereas the model calculates in five-year steps with annual sub-periods of the five years assumed to be exactly identical. Second, the data sources themselves do not agree and in the model, different sources are mixed. For example, the value of the macro-economic variables are compared to figures published by the World Bank, which has the longest time-series, but the input–output table which is used to produce these values is taken from national sources. Third, the input–output table for 1988 is used throughout the whole period, during which changes in the propensity to import in certain sectors, as well as domestic input into production, may have changed. For example, the propensity to import food, and the commercial margin added to food are probably higher in 1990 than in 1970. Fourth, the input–output table itself was changed from the original version.

In the original version, the value added in the agricultural sector was 5135 million 1990 Escudos. The World Bank estimate for value added in agricultural products in 1988 was 3492 million 1990 Escudos. Compared to national expenditure on food, and the low self-sufficiency ratio of Cape Verde, the national value added estimate appears too high, and imports of food too low. The unit vector of agriculture is therefore change so that value added in 1988 is 3492 Escudos, and agricultural imports make up the difference between the national and the World Bank estimates.

If the expected deviations are smaller than the deviations between the data sources, then the model results are found to be satisfactory on that score. Deviations in the data are quite large. In 1988, the World Bank estimates imports of goods and services to be 13850 million 1990 Escudos; the value in the input–output table is 15418 plus import duties of 1618 million Escudos. Two different national estimates for exports in 1988 range from 3579 million 1990 Escudos (National Accounts) to 5058 million Escudos (input–output table).

Table 9.3 reproduces the macro-economic variables of the model calculations and the historical data for the period 1970–1990. The model year 1970 is set with data from 1973, and the model-year 1990 with data from 1988. The table shows that the historical simulation gives good results for the final demand variables consumption, investment, government expenditure, and exports. The values for gross national product are always too low. The values for imports are too high in all years except "1970" compared to the World Bank data. The low gross domestic product and the high values for imports correspond to the higher propensity to import which is embedded in the input–output table compared to the World Bank data series.

Table 9.3 also shows the composite indicator variable consumption, which shows how much is consumed privately beyond subsistence consumption and which is, more than GDP per capita, the main economic indicator of this study. Variable consumption increased from 9287 1990 Escudos annually per capita to 27891 in the period "1970"–"1990", which shows an average increase of 5.5 percent. This is parallel to the 5.1 percent annual average increase in GDP.

9.1.3 Government expenditure

The historical scenario reconstructs the age-specific per capita expenditure on education, health, and general services or, bureaucracy. The total expenditure on these three items is provided by USAID (1976) and DGE (1989).

Assuming that the age-distribution (not: level!) of these three expenditure items remained the same (see Chapter 4), the historical scenario shows the following:

1. expenditure per pupil within each school level remained constant, the increases in education expenditure are due to larger numbers of pupils, not to more expenditure per pupil;
2. expenditure on health care per person in each age group remained constant, and increases are due to a larger population particularly in those age-groups requiring more health care;
3. the general expenditure, or bureaucracy, per capita increased almost eight-fold in the period 1970–1990.

9.1.4 Investments, capital, capital/output ratio, and employment

The level of investment, and the development of GDP in the historical period from 1970–1990, would lead to very high capital/output ratios if a depreciation rate between .04 and .05 were used. Such a depreciation rate would be in the range used in the PDE-Mauritius model, and other models such as Dayal (1981), and Forrester (1971). With this depreciation rate, and full use of all investments, the capital/output ratio in 1990 would be 3.6, which is outside values observed historically.[2] This means there is a portion of investment "disappearing". There could be a number of reasons for this:

1. inefficient investment, where the capital costs much more than the least-cost version because of bad management;
2. ineffective investment, where capital is put into a sector which cannot expand for other reasons;
3. investment that does not count towards increasing material capital or material output, such as reforestation, or making rain catchment gullies along hillside contours.
4. or, investments were lower than recorded.

It is known that there has been inefficient or ineffective investment, for example in the fishing industry, where millions of Escudos in foreign aid and donated ships have failed to raise the fishing output in twenty years. The extent to which this affected the economy is not known.

[2]Values published in Dayal (1981) showed an average capital/output ratio of 1.65 in Africa in 1960–1965; 1.79 in 1966–1970; 1.85 in 1971–1976. The highest regional value in 1971–1976 published in Dayal 2.79 in AFTA countries.

The large reforestation effort and anti-erosion and water-collection efforts in the period 1970–1990 indicate that the third case – that there was investment in the environment which did not count towards increasing material output – holds on Cape Verde. This indicates that the accounting of – material – capital/output could be an incorrect measure to follow the development of – material and natural – capital/output, because it counts only material output and not the value of natural output such as tree growing and water collection for natural aquifers, and leads to incorrectly assuming very high inefficiency or ineffectiveness in investment.

The model does not count for inefficient or ineffective investment, but it accounts for investment in the environment. A proxy can be made for the total amount of investment that is not used in the material output sector either through inefficiency, ineffectiveness, or investment in natural resources, by putting all these investments in the environmental sector. If 40 percent of the investments in the period 1970–1990 were invested in the environment, the capital/output ratio increases slowly during the period 1970–1990. Of this amount, 12 percent is accounted for by published water investments in the period 1980–1990.

9.1.5 Water investments

The historical scenario for water capacity and water investments is based on three main input variables: the amount of water used for irrigation in 1990, the capacity for drinking water distribution in 1990, and the total amount of investments which flowed into the water sector in the period 1980–1990. The model does not include sanitation coverage of the population. The government of Cape Verde however, is building up the sanitation capacity parallel to the drinking water capacity. Therefore, the drinking water capacity is used as a proxy for a more holistic water system. The costs of supplying this whole system are included in the drinking water capacity costs. All of the data for water investments is from INGRH (1993a and 1993b).

It is assumed that the subsistence level of water was available in 1970 to all the population, by virtue of this population having survived. However, the quality of the water at that time may have been, and probably was of an average much lesser quality than the water which is distributed now through the fountains. It is not known how much of the present capacity of 2.23 million cubic meters of drinking water was installed since 1970. It is, however, known that 90 million US dollars were invested in the water sector in the decade 1980–1990. This is equal to 6300 million Escudos, ignoring inflation and using the 1990 exchange rate.

Different assumptions about the proportion of the 1990 capacity that has been installed since 1980 lead to different estimations of average costs per installed unit of capacity. These costs can be compared to the projected costs for future projects.

If all of the 1990 capacity for drinking water distribution had been installed since 1980, the costs would be 2681 Escudos per cubic meter capacity, including sanitation, on average. The costs would be double, if only half of the 1990 capacity had been installed since 1980. The projected future costs, including sanitation are 1169 Escudos per cubic meter.

It is not possible to know, with published data, how much has actually been installed since 1980, and how much the average capacity costs are. They were, however, at least two and a half times as high as the costs which are projected for the future.

9.1.6 Conclusions – historical scenario

The historical scenario provides the following general insights:

1. The total fertility rate appears to have been at a lower rate in the 1970s than shown by the data, and to be at a higher level presently than indicated by the data. This means that the fertility decline has been less pronounced in the past 20 years than indicated by the data.
2. The large education expenditures since 1970 have not yet resulted in an equally large increase in the education investment received by the average worker, nor in a very large increase in the proportion of the labor force with secondary or higher education. This result is due to the momentum which was embedded in the poorly educated labor force of 1970.

3. The per capita education expenditure on pupils per level of school, and on health care per person in each five year age-category remained constant from 1970–1990, while per capita expenditure on general services increased eight-fold.
4. An estimated 40 percent of investments in the period 1970–1990 was used for environmental purposes, for water capacity building (12 percent of total investment), and "lost" through inefficiency or ineffectiveness. How much is accounted for by environmental purposes and how much by inefficiency and ineffectiveness is not known.
5. The 90 million US$ invested in water and the present capacity for water distribution indicate considerably higher costs for water capacity building in the past 20 years than forecast for the future.

9.2 Future PDE-Scenarios: General Considerations

The holistic future PDE-scenarios gather together all the information from the preceding chapters and sections – the qualitative analysis and the historical scenario – and synthesize it into possible stories for the future development of Cape Verde. This makes the future scenarios the collection of the most information-packed, compact statements in this study.

These scenarios are useful, within the limitations of the model, to explore the theoretical questions about the interaction between population, development, and the environment, but also to provide some general insights to the policy maker of Cape Verde.

The value of the future scenarios should not be over-estimated nor seen alone. The information which is contained in the qualitative analysis and in the historical scenario alone would be sufficient to develop other, different, and perhaps more valuable ideas about the future of Cape Verde, including different scenarios than those contained in the following pages.

The changes in the exogenous variable which are assumed in the model are guided by a combination of the hypotheses of transition (Section 7.2); the historical scenario (Section 9.2); the history of Cape Verde (Chapters 2–6) and the history of Mauritius (Lutz, 1994).

The hypotheses of transitions serve to guide the *direction* of changes assumed in the scenario. The speed of change, and the ultimate levels of the indicators are not pre-determined. The hypotheses of transition suggest the following directions:

1. fertility decreases from high traditional levels, or remains constant;
2. education transition rates increase or remain constant;
3. internal migration is from rural to urban areas until the majority of the population lives in urban areas;
4. industry and service production increase as a proportion of gross domestic product or remain constant.

The main conclusions from the historical scenario and the histories of Cape Verde and Mauritius are included in ways that are discussed in the description of each scenario.

The main questions to be addressed by the scenarios can be divided into two groups: those which concern population dynamics *per se*; and those which concern the interactions between population, development and the environment.

The questions concerning population change are:

Q1. What is the margin of population growth uncertainty from 1990–2025 for Cape Verde, i.e., how big is a "large likely" population and a "small likely" population and how far are their sizes apart in 2025. The term "likely" is a qualitative term and is not given confidence intervals or other quantitative value, following the reasoning presented by Sanderson (1994b).

Q2. What education developments are expected until 2025, and what proportion of these developments is certain, what proportion uncertain?

Q3. What is the effect of education on fertility and population size?

Q4. How will urbanization increase until 2025?

The questions concerning the interaction of population, development, and the environment are:

Q5. What are the interactions between population, development, and the environment? Are the effects, if there are any, of population on the economy and the necessary environmental investments different in a wealthier economy than in a poor one?

Q6. Can the Mauritius success story be replicated on Cape Verde? Do different water resource strategies and costs, and different population developments make a difference in terms of the GDP and variable consumption per capita? Is there room for greater food self-sufficiency investments?

Q7. Can Cape Verde's economy continue to produce above subsistence level consumption for the whole population even if the country is not successful at increasing its export level? Is greater food self-sufficiency with an irrigation water resource strategy feasible, and how large are the economic benefits?

The time horizon of the scenarios is from 1990–2025, which is 25 years shorter than the horizon used in the Mauritius-PDE study.

9.3 Population Scenario Assumptions

9.3.1 Assumptions

There are four population scenarios, two of which are based on the population scenarios used in the Mauritius-PDE study, and two are based on the "UN medium projection"

The "United Nations medium projection" (1992 version) of the population is reproduced. The United Nations is conservative about migration (most projections are zero migration) and this is true for the Cape Verde projections also. Given Cape Verde's history however, zero migration is the most *un*likely future. Therefore, a second "UN-migration" scenario complements the first which includes migration.

The two scenarios which follow the Mauritius-PDE scenarios are: one development towards "modern" fertility, mortality, and education levels; a second development towards "traditional" fertility, mortality, and education levels. The scenario assumptions are clustered in such developments following the demographic transition theory that such changes are connected and/or clustered.

The assumptions for 2025 in the original 1992 UN scenario are: life-expectancy increases to 72 years for men and 76 years for women in 2025; fertility declines to 2.23; migration is zero; and 55 percent of the population is urban.[3]

The assumptions in the PDE-Cape Verde model are different in structure from the UN because there are different socio-economic states in the population. This makes the scenario more complex. Life expectancy is assumed to be the same in all six socio-economic states, reflecting a healthy climate, fairly good nutrition overall, and a widely distributed net of health care centers. Fertility, external migration and internal migration differ per state following historical observation. Fertility for women with primary education is considerably higher than for those with secondary and this difference is assumed to remain. External migration is assumed to be higher among urban than rural people, and among those with more education. Internally, there is only rural-urban migration.

Replicating the UN scenario as closely as possible, the PDE-Cape Verde "UN" scenario assumes: life expectancy increases to 72 years for men and 76 years for women; fertility among the women with primary education or less declines to 3.15; fertility among women with secondary education and more declines to 1.53 (this results in total fertility of 2.13 in 2025); migration is zero; and the rural-urban migration rate remains constant as do the education transition rates.

[3]These assumptions have been changed from the 1988 version. In the 1988 version, life expectancy in 2025 was assumed to increase to 70 for males and 74 for females; fertility was 2.56; migration zero, and 80 percent urban.

Table 9.4. Assumptions for four PDE-Cape Verde population scenarios and the historical 1970 and 1990 values.

	1970	1990	2025 "UN" migration	2025 "UN"	2025 Traditional	2025 Modern
Life expectancy at birth	men: 55.1 women: 56.1	men: 63.9 women: 67.8	men: 72.3 women: 76.2 (annual mortality decrease 1%)	men: 72.3 women: 76.2	men: 63.9 women: 67.8	men: 72.3 women: 76.2
Total fertility rates	in-school: 6.15 primary: 6.15 secondary: 6.15	in-school: 5.23 primary: 5.23 secondary: 2.55	in-school: .04 primary: 3.15 secondary: 1.53	in-school: .04 primary: 3.15 secondary: 1.53	in-school: .7 primary: 5.23 secondary: 2.55	in-school: .04 primary: 3.15 secondary: 1.53
Rural-urban migration	all ages: .1	all ages: 1	5-9: .1 10-14: .2 15-19: .2 20-24: .2 25-29: .1 30-34: .1 35-39: .1	5-9: .1 10-14: .2 15-19: .2 20-24: .2 25-29: .1 30-34: .1 35-39: .1	5-9: .1 10-14: .2 15-19: .2 20-24: .2 25-29: .1 30-34: .1 35-39: .1	5-9: .1 10-14: .2 15-19: .2 20-24: .2 25-29: .1 30-34: .1 35-39: .1
School exit with primary education only	rural: .99 urban: .71	rural: .52 urban: .38	rural: .52 urban: .38	rural: .52 urban: .38	rural: .52 urban: .38	rural: .11 urban: .08
Net migration	Total: 19152	Total: 12596	Total: 6850	Total: 0	Total: 6850	Total: 6850

The "UN-migration" scenario is identical to the "UN" scenario except that net-emigration at half of the 1985–1990 value is assumed for the whole period from 1990–2025. This assumption may still be on the conservative side.

The "modern" scenario is essentially identical to the "UN-migration" scenario, except in education transition rates. It is assumed that the rate of children leaving school with primary education declines from 52 percent in rural areas and 38 percent in urban areas in 1990, to 11 percent in rural areas and 8 percent in urban areas. This change implies a 4 percent annual decrease in the drop-out rate during primary school, and de facto amounts to introducing mandatory school attendance until age 14, to be enforced by 2025.

The "traditional" scenario assumes constant rates throughout the period 1990–2025, including the same net-migration assumptions as the "UN-migration" scenario. Constant rates however, do not mean that in the aggregate everything remains fixed, as will be shown below.

Table 9.4 shows the assumptions for the population scenarios, and, for comparison, the historical 1970 and 1990 values.

9.3.2 Population scenario results

The population sizes which result from these scenarios range from between 534 thousand to 717 thousand in 2025. These different sizes are the result of different developments of fertility, mortality and migration. The developments of fertility, in turn are largely the result of changes in the educational structure of the population. This section discussed the population size, education, age-structure, fertility, and the proportion urban in turn.

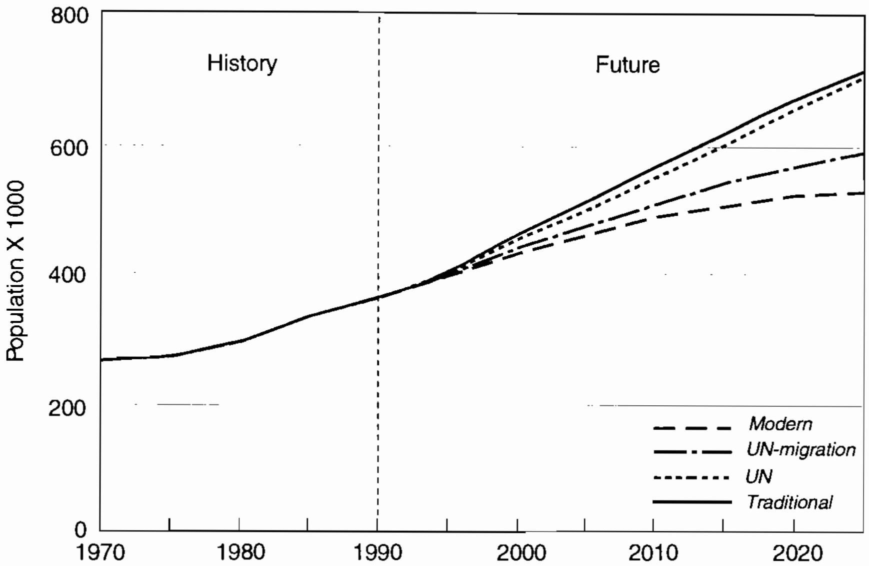

Figure 9.2. Population size in four PDE-Cape Verde scenarios. Source: model calculations, IIASA, 1995.

Population Size

The largest population in 2025 follows from the "traditional" scenario which is not surprising because of the continued high fertility rates and natural growth only somewhat modified by modest emigration. This population is 717 thousand, or, double the size of the 1990 population. Equally large is the "UN" population, where fertility declines, offset by simultaneously declining mortality, and which does not experience emigration. Although the numbers of emigrants are small – 1300 annually, compared to 2400 annually in the period 1985–1990 – in the small Cape Verde population they are large enough to offset a considerable amount of higher fertility.

The "UN" population according to these calculations is much smaller than the population calculated in the original UN version, which is 774 thousand. It was not possible within the scope of this study to locate the reason for this disturbing difference. Since the historical scenario replicated the UN data and even gave a slightly higher population in 1990 than the UN, with lower fertility rates, the difference for the future population scenarios cannot be due to incorrect computation in the model, which are the same for the historical and future scenarios.

The smallest population follows from the "modern" scenario. In 2025, with low fertility, low mortality, modest emigration, and high education, the population would be only 544 thousand, or 48 percent larger than in 1990. Moreover, by 2025, the population would be almost at a plateau, and on the verge of beginning a *decline*.

Somewhat higher is the "UN-migration" scenario, which differs from the "modern" scenario only in the education assumptions. In the "UN-migration" scenario, the population is 595 thousand in 2025, 62 percent larger than the 1990 population. The difference of 62 thousand people (more than 10 percent of the 2025 populations) between the "modern" and the "UN-migration" scenario is due solely to the higher secondary education rates which follow from the assumptions in the "modern" scenario.

Figure 9.2 shows the development of total population size under the four scenarios, and *Table 9.5* provides the figures.

Education

Education plays a powerful role in the dynamics of the scenarios because of the large observed difference in the fertility rate of women with primary and less education compared to those with secondary and more. It also plays a role in the internal and external migration of the country –

Table 9.5. Population scenario results 1970–2025 for four PDE-population scenarios and the UN medium population projection. Source: UN, 1993, and IIASA, model calculations, 1995.

	Population in six scenarios					
Year	UN original	Historical	"UN" migration	"UN"	Traditional	Modern
1970	267	272				
1975	278	280				
1980	289	302				
1985	324	339				
1990	363	369				
1995	419		406	417	411	405
2000	479		442	467	457	437
2005	540		478	520	506	468
2010	600		513	573	557	496
2015	659		545	625	609	520
2020	717		573	673	662	536
2025	774		595	717	717	545

those with secondary education are assumed to be the majority of the rural-urban migrants, as well as the international migrants. Further, education is assumed to be directly linked to labor productivity and thus exerts a powerful influence on the economic potential of the country. For these reasons, the scenario results on the education of the population are discussed previous to the age-structure, fertility, and urbanization results.

At the beginning of the scenarios' historical time horizon, 1970, Cape Verde's population was largely illiterate, and the transition rates of children into primary school, then into secondary and higher schools were very low, although literacy and other benefits of education had been spreading through the population slowly throughout this century. After independence, in 1974, the new government launched efforts to provide a formal basic education to all the population members, which was augmented by secondary education in the 1980s. These efforts have resulted in new transition rates into school and out of school, and have set an educational transition in motion, by the end of which – if it continues – the population of Cape Verde will be completely literate. The percentage with secondary education would be high, but as yet unsure.

In 1990, Cape Verde was still handicapped by a labor force with a high percentage of illiteracy – in 1990, 45 percent of the labor force was illiterate (DGE, 1993) – but this situation will change rapidly in the 1990s. By the year 2000 according to the "UN-migration" scenario the average education level of the labor force would improve considerably. In that year, 16 percent of the labor force aged 15–64 would have secondary education, and 69 percent would be literate.[4] This is an education level comparable to that of Mauritius in 1983, just before the economic take-off on that country. The reason for the fast change is due to the facts that: (1) the long maturation time of education investments made in the 1970s and 1980s will begin to pay off in the 1990s; and (2) the large size of the educated young cohorts who will enter the labor force from 1990 onwards, changes average education quickly through their large relative weight.

[4]The PDE-Cape Verde population module does not separate population by labor force participation. An estimate was made for literacy and secondary education by:

1. estimating the size of the labor force aged 25-75+ in 2000 by taking the 1990 labor force and multiplying by the general population survival rate age 15+ to age 25+ from 1990-2000;
2. assuming that the literacy and secondary education of this portion of the labor force is the same as in 1990;
3. assuming that the labor force participation of non-school population age 15–24 in 2000 is 98 percent for men and 45 percent for women (same as 1990);
4. that all of these young labor force participants are literate, and;
5. that the labor force participation of persons with secondary education is 100 percent for both sexes.

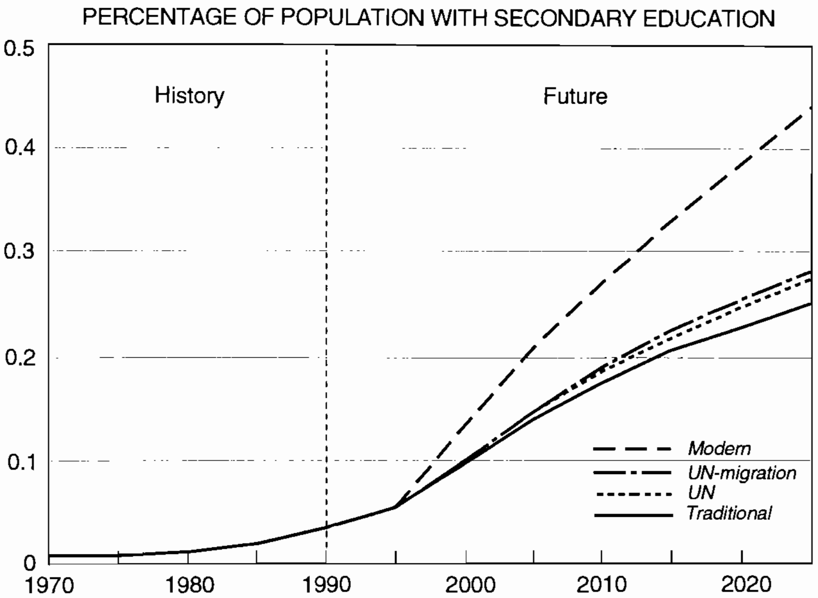

Figure 9.3. Percentage of the population with secondary education in four PDE-Cape Verde scenarios. Source: model calculations.

Figure 9.3 shows the percentage of the population with secondary education in the four scenarios. In the three scenarios with constant transition rates, the proportion of people with secondary develops parallel, with variations caused by differential fertility and migration levels. The proportion of people with secondary education increases very slowly from 1970–1995, and then begins to increase. By the year 2025, the curves in the three scenarios with constant transition rates are beginning to plateau, signalizing that a new level of stability is going to be reached reflecting the constant transition rates. The curve of the "modern" scenario is still steeply on the rise in 2025.

Age-structure, Aging and the Dependency Ratio

Due to the extremely small adult population compared to the population under 20, and to the still-high fertility rates which cannot drop immediately, Cape Verde will not experience extreme aging under any of the four scenarios before 2025. The most extreme aging would be from 5 percent of the population over 65 in 1990 to 11 percent in 2025 under the "modern" scenario. Under the "traditional" assumptions, the proportion of elderly would even remain constant. The percentage of the population over 65 is shown in *Table 9.6.*

However, a large shift in the age-structure and the dependency ratio – the ratio of elderly *plus* young persons in school or pre-school to the non-school population under 65 – will occur in the next decades, regardless of the scenario. These so-called dependency ratios have been correlated to economic potential (Prinz, 1992). Lower dependency ratios according to (e.g., Coale and Hoover, 1958) mean that higher savings and investments are possible. Furthermore, according to Lutz (1994) women with fewer children (and lower child dependency ratios) may mean that a larger portion of the non-school working age women is willing to work outside the domestic sphere.

Table 9.7 shows two dependency ratios. The first is a simple ratio of numbers of people: elderly plus young people in school or pre-school divided by the non-school population under 65. This is called the "normal dependency ratio (NDR). The second ratio is made following Prinz (1992:12) and includes assumed higher productivity of those with higher education in the dependency ratio. In this calculation, the assumed productivity of those with secondary education is twice as high as those with primary education or less – the denominator is: non-

Table 9.6. Percentage of the population with secondary education according to four population scenarios. Source: Model calculations.

Year	Historical	"UN" migration	"UN"	Traditional	Modern
1970	0.67				
1975	0.79				
1980	1.29				
1985	1.88				
1990	3.40				
1995		5.36	5.57	5.29	5.36
2000		9.92	10.09	9.58	13.65
2005		14.63	14.55	13.77	20.96
2010		18.97	18.50	17.39	27.24
2015		22.58	21.76	20.39	33.10
2020		25.61	24.64	22.93	38.64
2025		28.22	27.36	25.02	44.00

Table 9.7. Age structure events in four PDE-Cape Verde scenarios: proportion of population over 65; normal dependency ratio, NDR (school and pre-school population plus elderly over 65 divided by non-school population under 65); and education weighted dependency ration EDR (school and pre-school population plus elderly over 65 divided by non-school population primary education or less plus two times non-school population with secondary education or more. Source: Model calculations, IIASA, 1995.

	1970	1990		2025 "UN" migration	2025 "UN"	2025 Traditional	2025 Modern
Percentage over 65	4.8	5.3		9.4	8.4	5.3	10.5
NDR	.58	1.05	2010	.72	.69	.86	.69
			2025	.56	.54	.73	.52
EDR			2010	.55	.53	.66	.48
			2025	.40	.39	.52	.32

school population with primary or less plus two times the non-school population with secondary or more. This ratio is called the "education-weighted dependency ratio" (EDR).

Regardless of which ratio is taken, the table shows that in the past 20 years the dependency ratio on Cape Verde almost doubled, due to the combination of high fertility and high emigration of adults. In 1990, both the NDR and the EDR were at the highest historical levels. This means that regarding the dependency ratios, Cape Verde has been struggling an uphill battle for the past two decades.

1990, according to the model results was the zenith for dependency ratios, as *in all four scenarios* the dependency ratios decrease quickly and substantially in the next few decades. This is due to the large young cohorts moving into the non-school population while the cohorts which come behind them are not relatively as large and because emigration is not assumed to be as substantial in the future as in the past 20 years.

The dependency ratios decrease most slowly in the "traditional" scenario, as is expected with the high levels of fertility.

The other three scenarios tell a story about the costs and benefits of prolonged education. The decrease of the NDR is *not faster* in the "modern" scenario, compared to the two "UN" scenarios in spite of the fact that there are fewer children. This is due to the fact that in the "modern" scenario, people remain in school a number of years longer on average, thus pushing the dependency ratio up. At first sight, the conclusion would be that education does not benefit the productive potential of a population.

Table 9.8. Fertility levels in Cape Verde 1985–2025 according to the UN 1992 version medium projection and four PDE-Cape Verde scenarios. Source: UN, 1993, and model calculations.

Period	"UN" 1992 medium	"UN" migration	"UN"	Traditional	Modern
1985–1990	4.83	5.12	5.12	5.12	5.12
1990–1995	4.26	4.61	4.61	5.00	4.47
1995–2000	3.86	4.07	4.09	4.79	3.83
2000–2005	3.45	3.52	3.56	4.48	3.20
2005–2010	3.04	3.07	3.13	4.19	2.72
2010–2015	2.74	2.64	2.72	3.07	2.25
2015–2020	2.44	2.33	2.41	3.66	1.88
2020–2025	2.23	2.13	2.20	3.59	1.62

However, this conclusion would ignore the benefits of the higher productivity of people who have had more education. The higher productivity of people with secondary and higher education is expected to pay off in the long run which are shown by the development of the EDR. In 2010, the EDR in the "modern" is only 10 percent lower than in "UN" scenarios. However, by 2025, as education increasingly pays off, the EDR in the "modern" scenario is already almost 20 percent lower than in either of the two "UN" scenarios. If the scenario horizon were longer, one would see that this difference would increase.

Fertility Rate

The fertility rate in Cape Verde has been declining slowly since 1970. There has been a pronounced decline to just above replacement level fertility among women with secondary education or more. In 1990, total fertility was 5.12, according to the calculations made in Chapter 3. In the next few decades, each scenario envisions a further decline in the fertility rate. The declines in the scenario are due to two factors:

1. The increasing proportion of women with secondary and higher education, who are assumed to continue to have low fertility in the future.
2. The decline of fertility rates within the education groups.

If fertility remained constant within the education groups ("traditional" scenario), and the education transition rates also remained constant, then the total fertility rate would decline from 5.12 in 1990 to 3.59 in 2025, *purely on the basis* of higher education. The further fertility decrease within the education groups which is assumed in the two "UN" scenarios would bring fertility down to replacement. In other words, with the assumptions used in the PDE-Cape Verde "UN" scenarios, half of the fertility decline from 5.12 to replacement is due to increased education levels, and half is due to fertility declines within the education groups.

In the "modern" scenario, a very low fertility level of 1.62 is reached in 2025 by assuming the larger transition to secondary education which would result if the mandatory school age were increased to 14, as there are some plans in the Cape Verde Government presently. The extremely fast fertility decline, from 5.12 to 1.62 in 30 years would parallel fertility declines observed in Barbados, Hong Kong, Korea, and Singapore and would not necessarily be as fast, but would be continue further than the decline observed thus far in Mauritius (UN, 1993).

Table 9.8 shows the fertility levels from 1985–1990 which result from the model assumptions and calculations in the four scenarios. For comparison, the UN 1992 version medium projection is shown in the second column.

Proportion Urban

Under all three scenarios, the proportion of the Cape Verde population which is urban increases to around 60 percent in 2025. The similarity reflects the identical rural-urban migration assumptions in each scenario. The rural-urban migration is held constant throughout the scenario period at the 1990 level. The ultimate percentages of the population urban are similar to the values calculated by the UN medium population projection.

As the rural population becomes a smaller portion of the total population, the effect of rural-urban migration, which is based on the size of the rural population, on the total population location distribution also becomes smaller.

9.4 Future PDE-Scenarios

The holistic PDE-scenarios include assumptions about economic variables and investments in water and agriculture. Each holistic scenario has one of the population scenarios discussed in the previous sections.

Two groups of PDE-scenarios are considered in this chapter: those with an export boom equal to that of Mauritius; and those with stagnating exports. These scenarios are combined with different assumptions concerning agricultural investment; government expenditure; the investment rate and efficiency of investment; water distribution capital costs; population size and structure. The two clusters are discussed consecutively.

9.4.1 "Little Mauritius" scenarios

The export boom scenario is called "Little Mauritius". In it, the growth of the tourism and export manufacturing sectors as it was experienced in the 1980s on Mauritius is replicated. Three variants of the "Little Mauritius" scenarios above are run with the "UN-migration" scenario. One of the scenarios is also tested with the growing "traditional" population.

The "Little Mauritius" scenario is made with expensive water investments and cheap investments. The investments are a non-negligible portion of total investments and even of GDP, and whether or not water is cheap may make some difference to capital in the private sectors, and hence to the productivity of Cape Verde in general and in export in particular. Water investments can be seen as a proxy for all environmental investments.

The "Little Mauritius" scenario is made with two assumptions about the development of agriculture. One sub-scenario assumes that all of the irrigated area comes under drip irrigation, which doubles yields on the presently irrigated hectares. With the 50 percent water savings, the acreage of irrigated land is doubled in the next 20 years. The productivity per hectare is assumed to remain constant. This results in a two-fold increase of irrigated agricultural land output from the 1990 level. This development is compared to a "Little Mauritius" with further agricultural improvements, where productivity per hectare is doubled from 1990–2025.

Table 9.9 shows the assumptions of the "Little Mauritius" scenario and its variants.

9.4.2 "Little Mauritius" base scenario results

This is the "economic success" scenario. The main guiding principle of this scenario is that the exports grow just as fast as in Mauritius during the 1980s. One of the questions which remains is: when is the assumed start of this export boom?

The timing of the economic boom in Mauritius, from 1980 on, was at a point when the country was characterized by the following:

1. A large pool of well-educated young adults with a very high unemployment rate. Many of them were women. This coincided with a low fertility rate, which may have given women more liberty to seek work (see Lutz, 1994).
2. A small amount of import-substitution industry, built up during the 1970s.
3. 15 years of independence, during which time the political system of the country had established itself as a peaceful and mature democracy (Lutz and Wils, 1994). The country

Table 9.9. Assumptions of the "Little Mauritius" scenario.

Variables/Variants	1990	1995	2000	2005	2010	2015	2020	2025
Exports: energy, transportation, finance (%)	+5	+5	+5	+5	+5	+5	+5	
Exports: manufacturing (%)	+5	+5	+28	+22	+22	+10	+10	
Exports: tourism (%)	+10	+10	+15	+15	+15	+5	+5	
Agriculture: intermediate demand imports	3569	3813	4020	3560	4286	4960	5529	5813
Variable consumption rate	.329	.313	.298	.313	329	.346	.364	.383
	–1.0%	–1.0%	–1.0%	+1%	+1.0%	+1.0%	+1.0%	
Tax rate	obser.	5% flat	const.					
Education expenditure per pupil; education expenditure per person in age group; general expenditure per cap.	const.							
Domestic investment rate	.3	const.						
Remittances per emigrant	93000	50000	const.					
Net migration	12596	6000	const.					
Foreign public transfers	3517	3416	3334	3576	4286	5192	6086	7300
or:	–10%							
Labor productivity index	const.							
Water demand per unit of output, person, and unit of income	const.							
Agriculture investments total	0	234	679	1060	1060	1060	1060	1060
Costs of agricultural investments per unit	.033	const.						
Agricultural output increase per unit of irrigation water with investments	2	const.						
Drinking water capac. inst.	1000	500	500	1000	1000	2000	2000	2000
Costs	4234	1000	1000	2000	2000	4000	4000	4000
Type of financing	loan, 5% interest, half domestic, half foreign investments							
Population scenario	UN migr.							
Traditional population								
Variable consumption rate	.329	const.						
Tax rate	obser. +10%	5% flat	.082%	const.				
Expensive water investm.								
Drinking water cap. inst. installed	1000	500	500	1000	1000	2000	2000	2000
Costs	4234	3000	3000	6000	6000	12000	12000	12000
Variable consumption rate	.329	.313	.298	.283	const.			
	–1%	–1%	–1%					
Investment rate	.3	.4	const.					
Productive agriculture								
Agricultural output increase per unit of irrigation water with investments	2	2.2	2.4	2.6	2.9	3.2	3.5	3.9

was oriented toward exports for many years before the export boom started – the legal infrastructure for an export processing zone was set up 10 years before the export boom.

4. A regular, fixed flow of foreign exchange based on a trade treaty (the Lomé Convention) guaranteed by a fixed amount of sugar sales at a fixed price (Ramkissoon, 1994).
5. A certain amount of profit surplus – from sugar sales – which was invested in the two sectors – tourism and the textile industry – which led the economic boom. Foreign investment followed domestic investment.

It is not possible to establish, after the fact, which of these factors dominated in pulling the export boom, or if indeed completely different factors led to the economic success story of

Mauritius. However, these five factors were at least positive influences, even if they were not decisive.

Cape Verde does not have any of these characteristics in exactly the same form as they existed in Mauritius in 1980, although it may have in the near future.

1. There is high unemployment among young adults presently, but they are considerably less educated than the young adults in Mauritius in 1980. The population scenarios however, regardless of which of the four is chosen, project that the average level of education in adults will increase quickly in the next ten years. By the year 2000, Cape Verde will have education levels which approach those of Mauritius in 1980.
2. Import substitution was an important part of the economic agenda of the Government from 1974–1991. In the past few years, some domestic industry has sprung up, notably a beer and soft-drink factory, and a cigarette factory, both of which provided most of Cape Verde's supply of these products by 1994.
3. In the first 17 years of its independence, the country was led by a one-party Government who's priority was not export expansion. Since 1991 the country has a multi-party democracy, and is beginning to set up the legislation for large scale export production. In the Mauritius replication, a certain amount of maturation of this legislation is necessary.
4. There is a regular flow of foreign exchange, which comes from exporting services, remittances and foreign aid. It is likely that the country can count on a continuation of these flows, but the level is uncertain. In Mauritius, the sugar cane income was certain and sustained throughout the economic boom. At present, the sugar cane income still remains the same, but it is becoming less economically significant. A Mauritius replication would assume a continuation of Cape Verde's present foreign income in some form throughout the beginning of an export expansion.
5. There is domestic investment in the country, notably by the government in the past, but it is uncertain how high it is.

In the year 2000, the education level of the labor force is comparable to that of Mauritius and the export legislation has had time to mature. Therefore, a slow increase of exports is assumed for the period 1990–2000, followed by a boom. From 1990–2000 exports increase 5 percent annually, except tourism, which increases 10 percent annually, following present observations. In the 15 years from 2000–2010, the export expansion of manufacturing follows the path of increase observed in Mauritius from 1980–1990, which is around 25 percent annually.

In this scenario, the production increase, the income increase, and the population growth lead to higher water demand. The drinking water capacity is expanded, half funded by continued loans from abroad, and half by domestic investments. The costs of these investments are added to the total investments, which also include considerable amounts for the production expansion. The estimated costs are 2000 1990 Escudos per cubic meter capacity, lower than the low estimate for 1980–1990 costs, but higher than the planned investment costs.

One the one hand, technology has certainly improved in the past 20 years, as has the basic infrastructure and local technical know-how which are necessary to successfully install water distribution capital. This effect would make future capacity building cheaper than in the past. On the other hand, the investments of the past 20 years were able to take advantage of the most easily available water sources. This effect would make future capacity building more expensive. It is not possible, from the analysis of the existing data, nor from estimates made with the model, to make a statement about which of these two effects is likely to dominate the future. It is, however, likely that the actual costs of installing future water distribution capacity will be higher than those presently proposed in Cape Verde.

The gross national product in this scenario increases slowly from 1990–2000, and then expands rapidly in the next century, following the export boom. Gross domestic product increases from 20 billion Escudos to 85 billion in 2025. This is equal to 2000 US dollars per capita at the

1990 exchange rate (70 Escudos per dollar), which is just under the 1991 gross domestic product per capita in Mauritius (UNDP, 1994).

A large part of this gross national product is used for investments. Another part is used for government expenditure, for education and health expenditures, and for general services. The remaining portion for consumption is 52 percent of gross national product, 45 billion 1990 Escudos. The variable consumption in 2025 is 54 thousand 1990 Escudos per capita, compared to 28 thousand in 1990.

9.4.3 Large, traditional population

The default scenario is made with the UN-migration population scenario. How much difference would a different population scenario make? In the "traditional" population scenario, education develops in almost the same way as the "UN-migration" scenario, but fertility within the education groups remains constant, leading to a larger population. This population requires higher government expenditures for education, health, and general services, which are paid for with higher taxes. The taxes compete with consumption, and the higher taxes, the lower consumption. Moreover, within consumption, subsistence consumption competes with variable consumption. With a larger population, less resources remain for variable consumption.

The results of higher government expenditure is that the general tax rate is 8.2 percent, higher than the 5 percent flat rate in the previous scenario, from 2000 onwards. Gross national product is 86 billion Escudos, almost identical to the default "Little Mauritius" scenario. Total consumption is lower because of higher tax rates. It is 42 billion in 2025, compared to 45 billion Escudos with the smaller population. Because of higher subsistence consumption, variable consumption is 30 percent lower than with the "UN-migration" population. It is 38 thousand 1990 Escudos per capita in 2025. Comparatively, the population size difference is 20 percent.

9.4.4 Expensive water treatment

The water distribution costs in the above scenarios are the "low estimate". The "high estimate" is 6000 Escudos per cubic meters water distribution. The total investments in the other have to be higher than above, because the capital/output ratio in the non-water sectors is maintained at the same level as with inexpensive water costs. Therefore, consumption is lower.

In this scenario, total gross national product develops in almost the same manner as with inexpensive water treatment and is even slightly higher 88 billion Escudos. However, the costs of the investments are reflected in lower consumption. The variable consumption in 2025 with high water investment costs is 41 thousand Escudos, or, 25 percent lower than with the inexpensive water investments.

9.4.5 High agriculture productivity increases

How much difference does the agriculture sector make in the "Little Mauritius" scenario, where the economy is dominated by manufacturing and services by 2025? The alternative of doubling of productivity of the drip irrigated lands from the productivity which could be obtained today by installing drip irrigation is explored.

The requirements of the "productive agriculture" scenario are: that all of the irrigated land uses an irrigation procedure that is twice as water-efficient as the present average; that with the 50 percent irrigation water savings the acreage of irrigated agriculture is doubled from 2000 to 4000 hectare, and that the productivity of each unit of land doubles between 1990 and 2025. Note that this scenario does not require increases in irrigation water capacity.

In the "productive agriculture" scenario, maximum agricultural output increases to 11 billion Escudos, which is 90 percent of the *value* of subsistence consumption. This does not necessarily mean that Cape Verde is 90 percent food self-sufficient for two reasons. One, the total food consumption will be higher than subsistence in this scenario of income growth. Second, the type

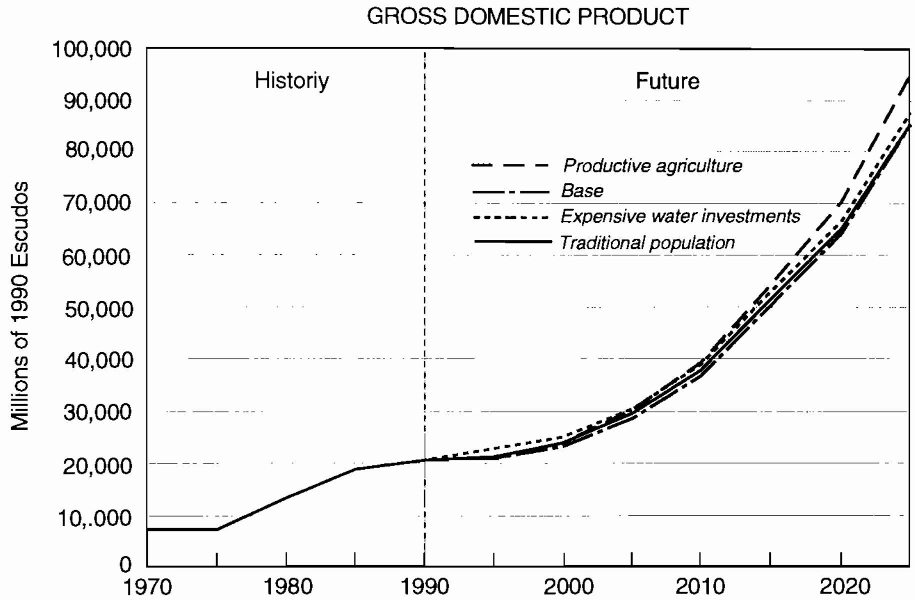

Figure 9.4. Gross domestic product in four variants of the Little Mauritius scenario.

of food that Cape Verde would grow with its intensive, irrigated agriculture would not include enough staples such as wheat, rice, maize to cover 90 percent of subsistence food requirements. These would have to be financed with trade in products from the domestic agricultural production.

In this scenario, contrary to the previous two variants, there is a gross national product effect. In 2025 under these scenario assumptions, the model calculates a gross national product of 95 billion Escudos, 10 billion Escudos higher than in the default "Little Mauritius" scenario. With the 1990 exchange rate, this is equal to 2300 US dollars. The gross national product increase is greater than the assumed agricultural output difference, which is 7 billion Escudos, because of multiplier effects.

The effect on variable consumption is even greater. Because food imports are much lower, the imports of non-food consumption items can increase, which means total variable consumption is higher. In 2025, in this scenario, variable consumption per capita is 68 thousand Escudos, or, more than 25 percent higher than in the default scenario.

9.4.6 "Little Mauritius" scenario variants comparison

Figure 9.4 shows the development of gross national product in the four scenarios, and *Figure 9.5* shows the development of variable consumption.

In the four variants of the Little Mauritius scenario calculated here, the gross national product trends are almost identical, regardless of population size, or environmental investments. The only thing that makes some difference is the increase of domestic production, here, in the "productive agriculture" variant.

The reason that gross domestic product development is so similar is because in the extremely open economy of Cape Verde, exports and other foreign income combined with the exigency of balancing imports to foreign exchange income largely determine gross national product. The economic actors in this system are competitive. Investments compete with private consumption through the trade balance; government expenditures are covered by taxes which are taken from private consumption; subsistence consumption competes with variable consumption.

The gross domestic product trend is continual growth. In the 1990s, the growth rate is 2.2 percent annually. In the period 2000–2010, gross domestic product growth is between 4.4 percent annually, which appears low compared to the large export increases. The reason it is so

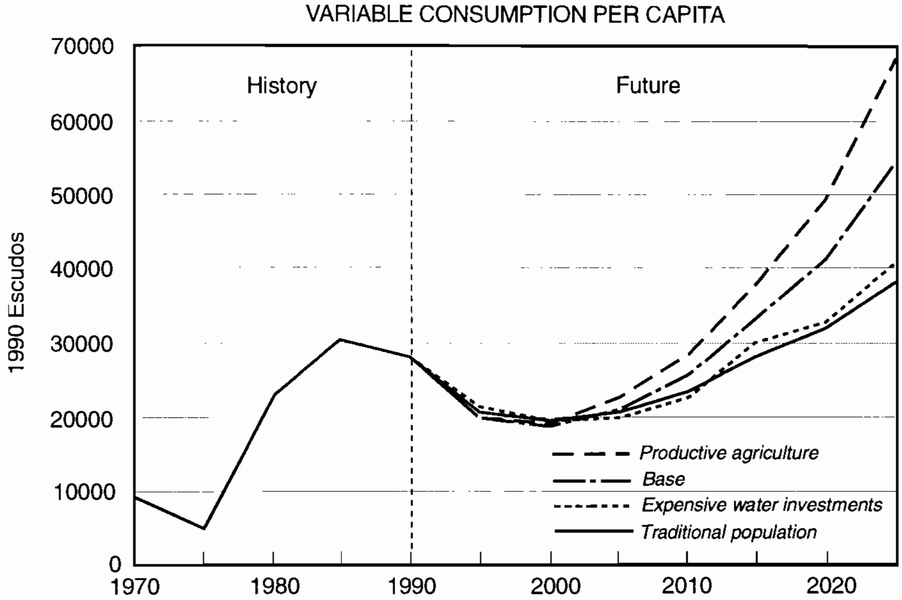

Figure 9.5. Variable consumption per capita in four variants of the Little Mauritius scenario.

low is because only a small portion of the total gross value of the exports is produced in Cape Verde itself – except in tourism – and because the growing manufacturing sector is initially so small and carries little weight in national economic growth. In the period 2010–2025, the average annual growth rate of gross domestic product is 5.4 percent in the scenarios with little agriculture output growth, and 5.9 percent annually in the scenario with productive agriculture.

Within the very similar gross domestic product trends however, there are very different distributions of the economic income between investments, government, and private consumers, and within consumption, there are different subsistence and variable consumption distributions. The effects of population size and environmental investments are visible in these distributions, and here, there are large effects. *Population size and environmental investments both have a large, negative effect on variable consumption.*

The effect of population size is that government expenditures on education, health and other services are increased (this is the same result as the Coale-Hoover model), and that these expenditures are paid for by taxes, and that taxes reduce private consumption. Additionally, within the smaller private consumption that remains, subsistence consumption takes up a larger portion because of the larger the population, and lastly, the smaller absolute value of variable consumption has to be divided over a larger population.

The effect of investments in water in these Cape Verde scenarios, is that – given an capital/output ratio trend from 1.0 to 3.0 in 2010 – total investments are increased, which raises imports of investment materials, foreign loans, and, subsequently, foreign debt repayments. The higher imports for investments compete with the foreign funds available to buy other imports, such as consumption goods. Given an equal trade balance trend, higher investments leave less imports for private consumption. Fewer imports for consumption decreases the domestic activity which builds on these imports, notably commerce, but also industrial activities which depend to 70 percent on non-commerce imported intermediate products. This ultimately means that the effect of investments to increase the gross domestic product is compensated by lower consumption.

The scenarios also show that the doubling of agricultural output *has a moderately positive effect on gross national product and a large positive effect on variable consumption.* The assumptions in the productive agriculture variant lead to a 12 percent larger gross national product in 2025 than the default variant, but to a 24 percent higher variable consumption.

Figure 9.5 shows the development of variable consumption in the four Little Mauritius variants, and the differences.

There is one important similarity between all four variants, and that is the *decrease in variable consumption from 1990–2000.* This decrease is a substantial 30 percent. How can this large decrease in variable consumption occur in a period when gross national product is increasing? A part of the increase is due to the fact that population is increasing faster than gross domestic product. Another reason, is because of the introduction of taxes to cover increasing government expenditure in a period when foreign public transfers are uncertain, and perhaps decreasing, and when exports are growing moderately, at 5 percent annually. Even without the tax increase however, variable consumption would still decrease because of the double effect of a larger population – to decrease the absolute amount left for variable consumption and to divide the smaller absolute over more people.

Following the beginning of the export boom, variable consumption in all four variants rises. In the period 2000–2010, the average annual increase is 1.9–3.9 percent annually, depending on the variant. In the later period, 2010–2025, the average annual increase is between 3.3 and 5.9 percent annually. The diverging rates of increase lead to ultimately very different values of variable consumption in 2025.

9.5 Stagnating Exports

The following set of scenarios is based on a future in which exports fail to increase at all beyond the 1990 level. Foreign public transfers also remain constant, as do remittances per emigrant.

This foreign income presently just covers the costs of imports, and, reflecting the long-term economic necessity that income (in whatever form) from abroad covers imports, the imports are also held constant. Holding the imports constant means that the investment rates or variable consumption rates cannot increase in this scenario.

In the default "Stagnating Exports" scenario, the "UN-migration" population is used. Agriculture output increases identically to the "Little Mauritius" scenario. The government maintains a constant level of general services, which means a decreasing level on a per capita basis. Education and health expenditures per capita remain constant as they have in the past. In the "Stagnating Exports" scenario, income hardly increases and far fewer investments in water are necessary because income hardly increases.

Next to the default variant, the "Stagnating Exports" scenario is calculated with two other variants: the traditional population; and productive agriculture identical to the previous scenario.

Table 9.10 shows the assumptions in the "Stagnating Export" scenario. All variables that are not listed are held constant at the 1990 level.

In the default "stagnating Exports" scenario, gross national product stagnates. In 2025, the gross national product is 19 billion Escudos. Investments decline in this scenario, reflecting the economic stagnation, and the capital/output ratio remains constant. Total government expenditures remain constant, but per capita expenditure are 2 percent lower every year. Agricultural output increases by 50 percent from its 1990 level in the period from 1990-2010, and thereafter remains constant. Food imports, which remain stable in the 1990-2010 period despite a growing population, increase again from 2010. Variable consumption declines constantly from the 1990 level of 28 thousand Escudos per capita to 12 thousand in 2025.

The "Stagnating Exports" is also calculated with the "traditional" population, with an identical investment rate as above, and an identical agricultural development. Gross national product is similar to that in the default variant, namely 19 billion Escudos in 2025. Due to the higher population growth, government expenditures are slightly higher than in the above scenario, and the tax rate is increased slightly from a flat 8.2 percent rate to 10.5 percent. Food imports rise more quickly than in the previous scenario, which, as discussed in the "Little Mauritius" scenario, competes with imports for other purposes such as variable consumption.

Table 9.10. Assumptions of the "Stagnating Exports" scenario.

Variables/Variants	1990	1995	2000	2005	2010	2015	2020	2025
Exports, foreign public transfers, remittances per emigrant	const.							
Variable consumption rate	.329	-1.%	-1%	-1%	-1%	-1%	-1%	-1%
Domestic investment rate	.3	.15	const.					
Education expenditure per pupil	-2.0%	-2.0%	-2.0%	-2.0%	-2.0%	-2.0%	-2.0%	
Health expenditure per person in age group	-2.0%	-2.0%	-2.0%	-2.0%	-2.0%	-2.0%	-2.0%	
Agriculture investments total	0	234	679	1060	1060	1060	1060	1060
Costs of agricultural investments per unit	.033	const.						
Agricultural output increase per unit of irrigation water with investments	2	const.						
Traditional population								
Variable consumption rate	.329 -2%	-2%	-2%	-10%	-10%	-10%	-10%	
Tax rate	obser.	5% flat	8.2% 1%	8.6% 1%	9.1% 1%	9.5% 1%	10% 1%	10.5%
Agricultural investments								
Agricultural output increase per unit of irrigation water with investments	2	2.2	2.4	2.6	2.9	3.2	3.5	3.9

Furthermore, the smaller variable consumption must be divided over a larger population. The model calculates that the variable consumption level decreases to a level below that calculated for 1975, to less than 5 thousand Escudos per capita in 2025. In this worst of all scenarios however, the average consumption of the population of Cape Verde is still above subsistence.

This result shows that *the effect of population size on variable consumption is large, negative, and in relative terms, it is larger when the gross national product per capita is lower.*

The "Stagnating Exports" scenario is also calculated with the UN-migration population and a productive agricultural sector. In this scenario, the increase in irrigated output continues. The economic market for this produce is the large, urban population, but the rural population also uses this produce for own consumption. As in the "Little Mauritius" scenario, it is thinkable that although the value of the agricultural output covers 90 percent of the subsistence demand, some international food trade may be necessary to obtain the right mix of food. In this scenario, the agricultural output increases as a proportion of total economic activity, which is contrary to the theory of an "economic transition".

As in the "Little Mauritius" counterpart of this scenario, the effect on gross domestic product is positive, and the effect on variable consumption is stronger than on gross domestic product. Both effects are larger in relative terms in the low gross national product scenario than in the high income scenario.

In the "Stagnating Exports" version of increased agricultural productivity, gross domestic product is 24 billion Escudos in 2025, which is 26 percent higher than without the agricultural productivity increase. The variable consumption level is 17 thousand Escudos per capita in 2025, which is 42 percent higher than in the default version of this scenario. It is still lower than the variable consumption level calculated for 1980.

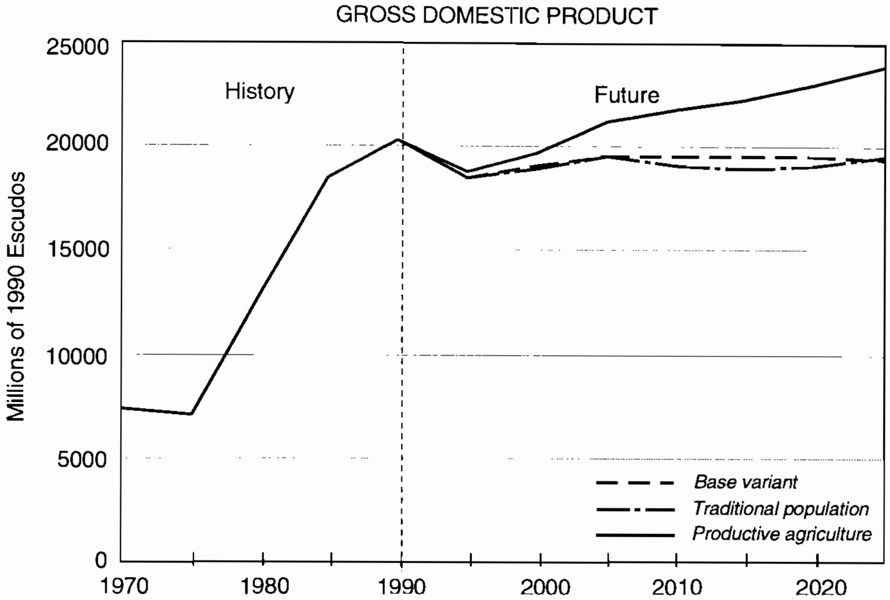

Figure 9.6. Gross domestic product in three scenarios with a stagnating economy.

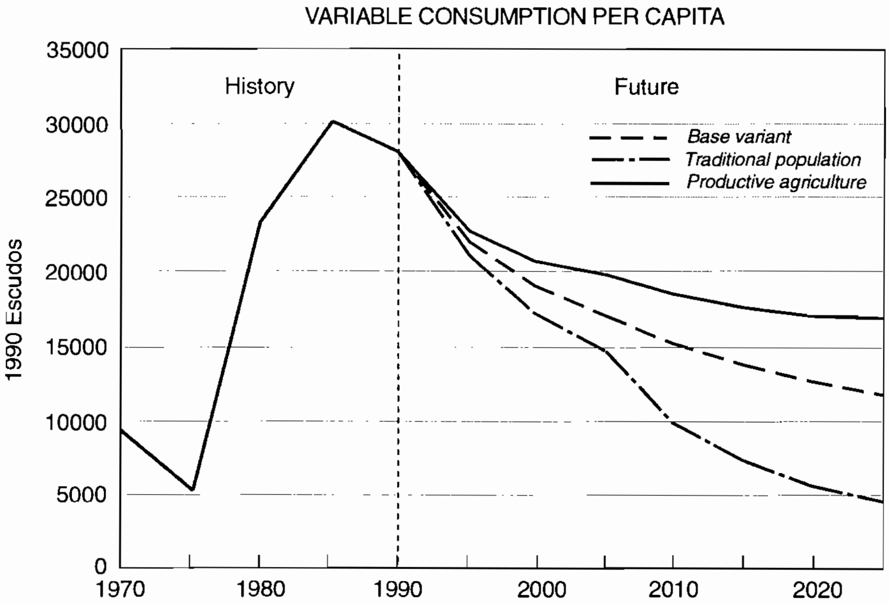

Figure 9.7. Variable consumption per capita in three scenarios with a stagnating economy.

9.5.1 Stagnating exports variant comparison

Figures 9.6 and *9.7* show gross national product and variable consumption per capita, respectively. In *Figure 9.6*, the constant level of gross national product in the "Stagnating Exports" scenarios with two different populations is shown. The absence of a population effect is due to the low domestic activity in these scenarios, and to the limits of maintaining a constant balance of payments that dominates the economy. The increased agricultural productivity scenario gives a gross domestic product that is 27 percent higher. The superficial conclusion would be that population has no effect on the population's wealth except that the wealth has to be divided over a larger population.

This conclusion is contradicted by *Figure 9.7* which shows variable consumption. This figure shows that variable consumption per capita would be 30 percent lower with 20 percent higher population in 2025. The effect of increased agricultural productivity on variable consumption is parallel to the gross domestic product effect, namely, 42 percent.

The variable consumption effects are relatively larger in the "Stagnating Exports" scenario than in the "Little Mauritius" scenario. With stagnating exports, the lowest level of variable consumption per capita is less than one-third of the highest level in 2025. In the "Little Mauritius" scenario, the lowest variable consumption per capita is 56 percent of the highest level.

The effects of lower or higher populations size on water demand is small in the "Stagnating Exports" scenario. This is partly because the relative population size differences are only 17 percent in 2025. More importantly, this is because the lower population has a higher income, and this increases water demand enough to offset the effect of the lower population size.

9.6 Conclusions

The effects of differential population size and high or low investments – within the open trade system of Cape Verde:

- *on gross domestic product are almost nil;*
- *on variable consumption are large and negative;*
- *are larger and more negative when gross domestic product is lower.*

The effects of increasing agricultural output, which implies import substitution, in the Cape Verde system:

- *are positive on gross domestic product;*
- *are positive and larger on variable consumption.*

The potential for increasing food self-sufficiency by improving the productivity of irrigated land are substantial. If Cape Verde succeeded in doubling the water efficiency of irrigation; using the saved water to expand the irrigated area from 2000 to 4000 hectares; and productivity on these 4000 hectares doubled between 1990 and 2025 then the value of agricultural output would be 90 percent of the subsistence demand for food by 2025 if population growth were moderate.

Chapter 10

Conclusions

The above 8 chapters describe Cape Verde, analyze the country, and point out processes that affect the dynamics of change, and the links between population, development, and environment. They have also given conclusions and summaries of the topics discussed. If done correctly, then the conclusions which are summarized in this chapter should be contained in the previous 8 chapters, and perhaps be evident already to the reader. This chapter contributes by organizing the insights of this study. It also points out where results from the Cape Verde study support those found in Mauritius, and where they diverge.

10.1 Population Growth: Escaping the Malthusian Trap

For 150 years, from about 1800 to 1948, Cape Verde was caught in what appears to have been a Malthusian trap or equilibrium. The Malthusian equilibrium is one where the given land area is so crowded with the population that only a meager subsistence level of production is ensured. At this subsistence level, mortality rates are high, so high that they cancel out the tendency of high fertility to increase population size.

Cape Verde experienced an altered, cyclical version of this equilibrium. In good years, say at the beginning of the cycle, the land offered slightly more than subsistence to the population, which had a high fertility rate. Births exceeded deaths and the population grew. The land became more crowded. Intermittently, a drought occurred, famine ensued and the population was reduced – to a level that could survive a drought. Then, the population was smaller than the hypothetical "Malthusian crowded subsistence" size population, and the cycle started again.

There is little evidence that the poor or the elite of Cape Verde intervened in this cycle by controlling fertility – as Condorcet might have suggested (see Chapter 7) – or by using the effect of high population density to introduce more productive technology – as Boserup might have suggested (*idem*). This does not lead the author to reject Condorcet's or Boserup's ideas as a whole. Rather, it appears that there are situations, such as that in Cape Verde, where they do not apply.

A few characteristics of the Cape Verdean situation explain this. Concerning fertility, Condorcet put forward that education of the population, particularly women, would give the people both the insight on the benefits of lower fertility, as well as the means to limit family size. Among the illiterate majority of the Cape Verdean population, this did not apply. Another author, Abernethy (1991), gives examples of traditional populations, namely the Inuit and the Polynesians, who controlled their fertility through an intricate system of taboos and restrictions on sexuality. This may not have occurred on Cape Verde because the population size was "controlled" by droughts and famines, and also, because the people of Cape Verde, uprooted from their original cultures and under a system of exploitative colonialism, did not have the opportunity to develop such binding and intricate traditions.

The exploitative colonial system also appears to be the reason that better technologies for agricultural production were not developed or introduced. As quoted in Carreira (1982), a governor at the end of the last century observed that the tenant farmers of Cape Verde – who were the majority – did not have the incentive to invest in their plots because "[a]ny tenant who improved his land and introduced long-term, extensive cultivation, could be sure that at the end of the year the proprietor would only consent to renew the lease in return for an increase in rent, so that it would be only he who derived any benefit from the improvements". Under the system of tenancy, the proprietors were likewise not motivated enough to invest in their property because a part of the profits would accrue to the tenant.

The Cape Verdean version of the Malthusian equilibrium was ultimately broken by two changes: emigration, and income and food from abroad, both discussed in that order.

Emigration changed the equilibrium in two ways: it removed people from the system, thus easing population pressure; and the remittances improved the incomes of those left at home. With the better incomes, the average survival rates of the people on Cape Verde may have been improved. If this was the case, then the effect emigration had on lowering the population size was compensated by higher natural growth due to higher survival rates.

Some authors, e.g., Abernethy (1991) have used this reasoning, plus the argument that emigration reduces perceived limits of the natural and national system, to argue that emigration keeps fertility high. In this view, emigration is not a sustainable strategy to solve problems of population growth and poverty, and more, ultimately exacerbates these problems. The conclusion is that emigration should be stopped by limiting the immigration possibilities in the receiving countries.

In the case of Cape Verde, this reasoning would have been callous in the face of the real possibility of starvation if remittances were reduced. There are other arguments which actually support emigration from Cape Verde. Since most migration from Cape Verde appears to be temporary (see Section 3.3), one could venture the hypothesis that emigration to low-fertility countries exposes the migrants to a culture of family limitation, which they might, particularly in the case of female migrants, take home with them as a new value. A second argument is that labor emigration of women may directly lower total fertility. Most of the women who go abroad to work, are in their prime child-bearing ages. Almost certainly, they reduce their fertility while abroad, and probably often postpone family formation until their return. If this is true, then the "real" total fertility rate of Cape Verde is lower than is measured nationally, because the national measurements exclude the low-fertility period when female labor migrants are abroad. This argument makes a case for supporting temporary female labor-migration specifically.

If emigration were stopped immediately, the economic consequences on Cape Verde would be grave, since remittances presently supply up to one-fifth of GDP (see Section 5.4). The economic shock might endanger the process of social development which, it is argued below, is necessary for Cape Verde to have the chance to nurture its export industry to maturation.

The second factor which broke the Malthusian equilibrium was foreign aid, which arrived in large amounts after independence, from 1974. With these funds, food could be imported from abroad. Together with direct food-aid, foreign aid funds allowed Cape Verde to avoid the specter of famine.

Foreign aid was administered by the government in a food-for-work program. The imported food was sold to the people, and with the proceeds, government employed large numbers o laborers in infrastructure construction works. This eased poverty directly. It might also have contributed strongly to the fact that agriculture did not expand, since the 1970s despite high population growth (see Section 5.2). The stagnation of agriculture may be related to the food-for-work programs in two ways, one positive, one negative. One farmers did not expand to more fragile lands as much as they might have without the possibility to work in the public construction scheme. In other countries (e.g. the Philippines, Brazil) the expansion of agriculture to fragile lands has considerably endangered the environment there. Second, as agriculture was less vital than it would have been without the public scheme, there may have been reduced motivation to improve cultivation methods.

One might argue along the same lines as with emigration, that as long as fertility remains high, foreign aid is not a sustainable strategy because the population grows without a stronger or larger economic base from which to live. This is true only if foreign aid is not used to strengthen the economic base of a country. In the case of Cape Verde, the foreign aid appears to have been well-invested in infrastructure and education, creating the necessary base on which economic development can build.

10.2 The Fixed-Pie-Size Economy

Cape Verde has an economy which is dependent for up to fifty percent of its GDP on external sources – remittances, foreign aid, and exports. By itself, such openness is not unusual for a small country. In the strong economy of Mauritius for example seventy percent of GDP is exports and imports (Wils, 1994c). In Cape Verde, the large proportion of foreign aid indicates a weak and open economy. Whether *weak* or strong, the more open an economy is, the more it is dependent on and influenced by *external factors*, meaning, e.g., the economy, the political situation of those foreign countries to which the small national economy is tied.

The external income – be it from remittances, foreign aid, or exports – is used to import goods and services. The amount of imports which a country can afford, and how these imports are integrated in the economy is a strong determinant of the size of the economy in an open economy. The value of imports is limited by the amount of foreign exchange generated, in other words, the balance of payments needs to be more or less zero.

The imports are used to generate income – a commercial margin in the case of final goods which are sold directly to final users, or production value added in the case of imported intermediate goods. Depending on the economic structure of the country, the imported goods can be used to generate more, or less income. A country with no industrial capacity will import all final industrial goods and gain only the commercial margins from selling them to the final users. A small country with industrial production capacity can import intermediate goods and generate income from processing them.

The restriction of imports limits the size of the GDP pie. The larger the proportion of GDP that goes into imports, and the larger the proportion of final goods among the imports, the stronger the limitation. In a country like Cape Verde, where imports are equal to up to 80 percent of GDP and more than half of them appear to be final goods, there is a virtually "fixed-pie-size" economy, that is, almost completely determined by its capacity to buy imports, rather than on internal mechanisms. In the fixed-pie-size economy, the various national actors who consume – namely, the government, the investors, and private consumers – are competitors. If one of these actors arranges to obtain a larger slice of the pie, this means there is less remaining for the other two. The fixed-pie-size and the resulting competition dominate the economic effects of population growth and environmental resource use, as discussed below.

The mechanisms of Cape Verde's open economy are explored in the future scenarios with the PDE-Cape Verde model. One of the requirements in scenario formulation is that the balance of payments be zero, or close to zero (see Section 9.4).

Two scenario groups were produced, the "Little Mauritius" scenarios, and the "Stagnating exports" scenarios, one simulating economic growth, and one economic simulation. Within each group, variations were calculated with different population sizes; high and low costs of water investments; and moderate or large agricultural productivity increases. Within each scenario group, the variations of population size and environmental costs made almost no difference to total GDP. Only the variations in the productivity of agriculture raised or lowered GDP.

The explanation for this is that the population size and the environmental costs did not change Cape Verde's productive capacity, and largely shifted import demand from one type of imports to another, and thus, in the fixed-pie-size world, the effects of the variations was to redistribute income.

The redistribution effects are considerable, particularly in the variable which was used to measure individual material welfare, namely variable consumption per capita. Variable consumption is that portion of private expenditures which remain after subsistence has been guaranteed.

It is believed to be a more preferable measurement than GDP per capita for two important reasons:

1. GDP per capita included government and investment costs which do not necessarily benefit the individuals in the economy. Particularly investments – such as environmental clean-up – do not benefit private consumers' welfare. One can argue that government expenditure increases individual welfare, which it certainly can do in the case of, e.g., education, health, public transportation. Therefore, one could also use "private consumption plus social expenditure" per capita.
2. Within private consumption, there is a portion which is used to assure basic subsistence. It is assumed that anything less than survival has a welfare value of negative infinity. At survival, welfare is exactly zero. Therefore, it is only beyond the level of subsistence that one can begin to speak of increases in material welfare.

Population growth has a strong, negative effect on variable consumption per capita. First, the larger population requires greater government outlays in the form of education, health care, and general services. These outlays are paid for by taxes, which are extracted from incomes. Thus, there is less total income remaining for private consumption. (This effect disappears if public social expenditure is included in consumer welfare). Second, the larger number of people all require a subsistence income to survive. As there are more people, more subsistence income is subtracted from the already smaller total income remaining for private consumption. After these two effects, the slice of the pie remaining for variable consumption is considerably smaller the larger the population. Third, this smaller slice has to be distributed over more people, which further reduces variable consumption per capita. This mechanism is similar to the one developed by Coale and Hoover (1957) for India, whereby they considered education more than subsistence.

A simpler mechanism functions with environmental investments. Higher environmental investments – for Cape Verde, only water investments are used – reduce the total income remaining for private consumption. The smaller slice has to be distributed over the same number of people. Thus the effect of higher investments is less complex than that of a larger population.

10.3 Fixed Water Resources

In the Cape Verde system, the environmental resource *per se* is water. Virtually the entire water supply of Cape Verde comes from rainfall – excepting a small amount which condenses as dew, and the ocean water which is desalinated. Most of the rainfall evaporates or is lost in torrential floods into the ocean. A little less than 15 percent collects annually into natural aquifers. The water turn-over in the aquifers is relatively fast, 1–3 years. Those aquifers which are accessible present the water supply of the people of Cape Verde.

Typical of this water supply is that it is determined exogenously by the climate, and that it arrives in the form of clean, usable rain water. This means that (1) the supply is fixed and renewable per time period; and (2) there are no cumulative effects of pollution or over-exploitation.

These characteristics are very different from: non-renewable resources which are not fixed and renewable per time period, but fixed in eons of time; and renewable resources with populations, such as fish, which are cumulatively affected by pollution and over-use.

Because the water is renewed every year with clean rain, it does not matter to the environmental system of Cape Verde *who* uses the water – whether it is a polluting micro-chip industry, or a house-person doing the laundry. Once the water is used it exits the Cape Verde system into the ocean (in the ocean of course, pollution can set off a chain of events of its own). In this peculiar situation, it does not matter whether use of the environmental resource, water, increases because there is population growth, or because there is economic growth.

This may lead the reader to object that the case of Cape Verde therefore has no general insights to offer for other case countries. However, the author believes that the extremity of the Cape Verde case allows us to see some dynamic which may otherwise be over-looked: the consecutive competition for scarce resources. Consecutive competition occurs when there is competition for a resource, causing a bottleneck which can only be resolved by introducing competition for another resource.

With a fixed resource, like water on Cape Verde, an annual round of competition for the resource – water – occurs if the potential demand is greater than the supply. The competing users of water on Cape Verde are: irrigation, livestock, private consumers, and commercial sectors.

If there is a water shortage, one of the competitors must give way – either, e.g., commercial users cannot expand as they would like to due to the water bottleneck, private consumers have to conserve on their washing, or agricultural production decreases.

Another solution to a water shortage is to invest in water facilities – these can be, e.g., reservoirs, desalination plants, or water-recycling and water efficiency equipment. Such investment alleviates the water bottleneck.

However, as was shown in Section 10.2 above, higher investment constrains demand from the government and/or private consumers because it siphons off limited economic resources (on Cape Verde: limited foreign exchange). Therefore, although a water shortage can be over-come, there are high environmental costs to private consumers – even if total GDP increases somewhat as a result of the investments – in the form of foregone disposable income.

10.4 Women, Work, Education, and Fertility

Education, particularly of women, is important for two major reasons. The first is that it increases the productive potential of the educated person, which benefits society and the individual. The second is that education of women increases their status, and this can lead them to desire fewer children and to implement this desire. If high population growth is straining the resources in an area, or globally, then education of women is an important element in reaching lower population growth rates.

On Cape Verde, the correlation between low fertility and high education is also observed. The women with secondary and tertiary education had a fertility level close to replacement (2.6 children per women); whereas the women with no or elementary education only had a fertility level around 6 children per woman. It is interesting to note that on Cape Verde, there is no correlation between basic education and lower fertility – the correlation begins only with secondary education.

It could be hypothesized that the continued high fertility of women with primary education is due to the fact that they are working in agriculture, where children can act productivity from an early age and are thus an economic asset. This is contradicted by the facts about women's location, work, and children's schooling. Urban women with primary education had similar fertility rates as women in rural areas, and more than half of the working women were active in non-agricultural sectors. Further, most children in the age-group 5–9 and a large group in the age-group 10–14 was in school, and thus could contribute less to family income.

The high fertility of women with low education in Cape Verde does not inhibit their labor force participation rate. The labor force participation rate of women on Cape Verde, despite many children, is higher than that of Mauritius in 1990. This may be related to the pattern where many women on Cape Verde have children but do not live in union. One can hypothesize that in this situation, the economic necessity of acquiring an income over-rides the necessities of maternal child-care.

At the same time, one can also hypothesize that the fact that many men do not need to be responsible for their children absolutely inhibits any desire they may have to limit their number of children. Many verbal sources on Cape Verde attested that to have many children

– illegitimate or not – is a sign of male virility and something to be proud of. Why then, do the women not limit their family size, if they can expect to carry most of the responsibility of raising them? Because, attest the same verbal sources, there is a chance that the father of the child may take lasting responsibility for it, either by living with the woman, or by sending child-care payments. For a woman, then, to have a child from a man, is similar to a lottery – there is a *chance* that you may gain considerably. At the same time, the costs of raising children are apparently not so high – perhaps education even lowers them as children of poor mothers receive a free lunch in school, and do not require supervision during the time that they are in school.

All this together may explain the situation of relatively high female basic education levels, high female labor force participation rates together with high fertility. It is apparent that secondary education on Cape Verde provides young women a different choice.

It can be expected that because of faster increases in secondary education among child-bearing women – which is evident in the secondary school participation rate of girls – fertility will fall more quickly in the next few decades than it did in the previous two.

10.5 Cape Verde on the Way to Little Mauritius

Cape Verde would double income if it had the same export boom as Mauritius. This would take at least another 5–10 years to begin because Cape Verde is not at the point yet where Mauritius was at the beginning of its economic boom in multiple respects. There are five reasons the author believes that such an export boom on Cape Verde will take at least another half decade to materialize.

1. There is high unemployment among young adults presently, but they are considerably less educated than the young adults in Mauritius in 1980. The population scenarios however, regardless of which of the four is chosen, project that the average level of education in adults will increase quickly in the next ten years. By the year 2000, Cape Verde will have education levels which approach those of Mauritius in 1980.
2. Import substitution was an important part of the economic agenda of the Government from 1974–1991. In the past few years, some domestic industry has sprung up, notably a beer and soft-drink factory, and a cigarette factory, both of which provided most of Cape Verde's supply of these products by 1994.
3. In the first 17 years of its independence, the country was led by a one-party Government who's priority was not export expansion. Since 1991 the country has a multi-party democracy, and is beginning to set up the legislation for large scale export production. In the Mauritius replication, a certain amount of maturation of this legislation is necessary.
4. There is a regular flow of foreign exchange, which comes from exporting services, remittances and foreign aid. It is likely that the country can count on a continuation of these flows, but the level is uncertain. In Mauritius, the sugar cane income was certain and sustained throughout the economic boom. At present, the sugar cane income still remains the same, but it is becoming less economically significant. A Mauritius replication would assume a continuation of Cape Verde's present foreign income in some form throughout the beginning of an export expansion.
5. There is domestic investment in the country, notably by the government in the past, but it is uncertain how high it is. Domestic investment was important on Mauritius because it made an economic base and provided the Mauritians with entrepreneurial experience.

The ultimate gross domestic product per capita would still be lower than on Mauritius because of the lack of agricultural exports which are cushioning the economy and creating a high rate of domestic value added to gross product whereas industrial products have a low value added: product ratio. And because Cape Verde has so little domestic production, that it loses much of its income abroad through imports. The situation would be considerably improved if

Cape Verde would also improve its agricultural output (4-fold increase in the scenario) because more income would be generated to circulate within the country.

Remittances and foreign aid were vital in the most basic sense of the word during the 1970s. Income was used for investment, e.g., in water, reforestation, which would not have been possible otherwise.

In the period 1985–1990, foreign aid decreased considerably in real terms which created an impression that the economy of Cape Verde was in a recession just at a time when it was increasing domestic activity considerably.

The scenarios show that if Mauritius is at all a "how to" case for export success, then Cape Verde will wait another 5–10 years before its educational, legal, and perhaps other conditions match those of Mauritius at the beginning of its export boom. In the interim, due to continued population growth, and slowly increasing exports, a continued decrease of foreign aid, as it occurred from 1985–1990 would decrease variable consumption by 30 percent between 1990–2000. This decrease would not show up in gross domestic product, which would continue to increase, albeit slowly. However, consumers would feel the effects of lower disposable income beyond subsistence. This, coupled with high unemployment levels, could lead to political instability and endanger the democracy of the country. It would therefore be advisable that foreign aid is continued at its present levels until the year 2000.

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Appendix A: Population Data Available

Table A.1 shows the population statistics on Cape Verde that are the basis of this chapter.

Table A.1. Population statistics on Cape Verde.

Variable	Years available
Total population	1582, 1731, 1807–1990 (most years)
Age- and sex specific population	1960, 1970, 1980, 1990
Total number of births	1860–1926 (various years), 1927-1992
Births by age of mother	1960, 1970, 1983–1988, 1990–1992
Births by age of mother and island	1983–1988, 1990–1992
Total number of deaths	1860–1926 (various years), 1927–1992
Deaths by age	1970–1971, 1976, 1983–1992
Infant deaths only	1912–1992
Deaths by cause	1960–1963, 1983–1988
Total emigration	1900–1992 (most years)
Total immigration	1933–1992 (most years)
Contraception use by method and island	1984–1992

Data on births and deaths in the last century and partially in this one, indicate a much lower population growth than the data on population size. The available data on population size, births, and deaths shows that the data on births and deaths have little to do with increments in population size. For example, in 1885, there were 4718 births registered, and 1834 deaths, a natural increase of 2884 persons. In 1885, the population was estimated 110926 and in 1886 it was estimated at 117556, an increase of 6630 persons. The difference could lie in migration, but there is no mention of large immigration streams at the end of the last century in the literature. In 1886, births were 3771, deaths 2175, a natural increase of only 1596, while the population in 1897 was 117630, and increase of only 74. Besides the unlikely high fluctuation in births, it is unlikely that in this year there was an emigration of over 1500 people, as in this time, emigration to the United States had only just begun and in the highest years at the beginning of this century was seldom over 2000 persons annually. Other years in the nineteenth century pose similar problems.

It may be that the inconsistency arises because periods covered by the data are different. Usually births and deaths cover the period from the beginning of the year x to the end, so that the correct total populations to compare would be the population at the beginning of year x and at the beginning of year $x+1$. But perhaps population was not always counted on January 1. It is thinkable that the 110926 in 1985 concern January of that year, while the 117556 of 1886 concern December, a time span of almost two years. Then, the data for 1887 could be from January of that year again, a time span of only a month. If this were true, then the birth and death data could be right, even if one could not compare natural growth in a year with the supposed population increase. This problem could be half-solved by taking longer intervals, say of ten years. In the longer interval, the problem of date of measurement within a single year is less urgent. If one does not know the date of population measurement, then the possible time span between the two measuring points is equal to the actual interval n plus or minus one year:

$$\text{Possible interval} = \text{year } x + n \text{ - year } x \text{ +/- } 1$$

With a longer time interval, the possible error becomes relatively smaller. For example with a one-year time interval, the measurement error of up to a year (one year too short or one year too long) is 100 percent of the interval measured. With a ten-year interval, the measurement error is at the most 10 percent of the interval measured.

However, even taking the ten-year interval, and making reasonable interpolations for births and deaths in missing data years – such as taking the average of the last and the next year data was available – there is still a great shortage of natural growth measured compared to estimated population growth in the period 1860-1900. As this is a period with no mention of immigration, it is probable that deaths, and more so births, were under-registered in that period.

It is likely that both births and deaths were under-registered because such registration cost time and money and in remote areas perhaps considerable trouble. It is likely that grosso modo the numbers on the population size are in the correct range. Therefore, these numbers can be taken more seriously than births and deaths and resulting rates.

Appendix B:
Cause-added and Cause-decreased Life Tables

The cause-added life table is used to answer questions such as: How will life expectancy be affected if AIDS increases; if there is a resurgence of malaria; if famines occur? It is an adaptation of the cause-deleted life-tables discussed in, e.g., Keyfitz (1986):48–52). Cause-deleted life-tables are used to answer question such as: How will life expectancy be affected if AIDS is eliminated; or if all cancer is cured? The cause-decreased life-table is similarly an adaptation of the cause deleted life table, and is used to answer questions such as: How much of the life expectancy increase in the past decade is due to a reduction in deaths from cardio-vascular diseases?

This appendix first reviews the cause-deleted life table briefly before turning to the two adaptations.

To eliminate a cause of death from the life-table, one cannot simply subtract the cause specific rates from the total death rates,

> If a person dies of one cause, he cannot die at some later time of another; the literature speaks of competing causes of death. Since dying of a given cause avoids exposure to other causes, if we wish to know what the mortality from these other causes would be if the given cause were deleted, we need upward adjustment to the observed rates. Over a finite interval of time or age it would be incorrect to delete a cause simply by neglecting all deaths from this cause and calculating the life table from the remaining deaths: such a procedure would give too low mortality from the remaining causes. We need an estimate of exposed population that does not include persons dead of the deleted cause. To make the estimate it is customary to assume that the several causes act independently. [Keyfitz, 1985:48]

Keyfitz uses the analogy of a watch to make this clear:

> Think of a watch or other machine having parts and operating only as long as all the parts are functioning. Each part has its own life table; the chance that the ith part will operate for x years is $l^{(i)}(x)$, calculated without reference to other parts. Then the chance that the watch will still be going x years after its births is
>
> $$l(x) = l^{(1)}(x) \cdot l^{(2)}(x) \cdot \ldots \cdot l^{(1)}(x) \quad ,$$
>
> [Keyfitz, 1986:48]

To simplify, only two causes of death are distinguished, cause i, and all other causes $-i$. The survival probability to age $x+n$ from age x is then

$$\frac{l_{x+n}}{l_x} = \frac{l^i_{x+n}}{l^i_x} x \frac{l^{-i}_{x+n}}{l^{-i}_x} \tag{B.1}$$

and

$$\frac{l_{x+n}}{l_x} = \exp[-\mu(x+t)dt] \tag{B.2}$$

where $\mu(x+t)$ is the mortality at exact age $x+t$. Equation B.2 applies to $l^i(x)$

> just as it does to $l(x)$; hence, as pointed out by Jordan (1952:258) and Chiang (1968:246) we have:
>
> $$\begin{aligned} -\ln \frac{l^{-i}_{x+n}}{l^{-i}_x} &= \int_0^n \mu^{-i}(x+t)dt \\ &= \frac{\int_0^n \mu^{-i}(x+t)dt}{\int_0^n \mu(x+t)dt} \int_0^n \mu(x+t)dt \\ &= R\int_0^n \mu(x+t)dt \end{aligned}$$
>
> say, and, on multiplying by -1 and taking exponential of both sides,
>
> $$\frac{l^{-i}_{x+n}}{l^{-i}_x} = \left[\frac{l_{x+n}}{l_x}\right]^R \quad .$$
>
> . . .
>
> Chiang (1968) takes R simply to be the ratio of the age-specific rates for the interval. [Keyfitz, 1986:50]

$$R = \frac{M_{x,n} - M^i_{x,n}}{M_{x,n}}$$

Cause-added Life Table

The same argument can be made if rather than μ^{-i} one used a mortality rate with a cause added or, μ^{+i}. Then, R would be equal to

$$R = \frac{M_{x,n} + M^i_{x,n}}{M_{x,n}} \tag{B.3}$$

Can this simply be done? Yes, as shown by the following argument.

Imagine the above procedure had just been completed, and a new, higher life expectancy calculated without cause of death i. This life expectancy and the accompanying probabilities of survival, $l^{-i}(x)$, the new standard. Later, the student wants to undo the elimination, to reinsert the cause, or, to *add* the previously eliminated cause to the new standard.

The logarithm of the new standard is

$$\ln\left(\frac{l^{-i}_{x+n}}{l^{-i}_x}\right) = R\ln\left(\frac{l_{x+n}}{l_x}\right) \tag{B.4}$$

Reinserting the cause of death i,

$$\ln\left(\frac{l^{-i+i}_{x+n}}{l^{-i+i}_x}\right) = \bar{R}\ln\left(\frac{l^{-i}_{x+n}}{l^{-i}_x}\right) \tag{B.5}$$

where

$$\bar{R} = \frac{(M_{x,n} - M^i_{x,n}) + M^i_{x,n}}{M_{x,n} - M^i_{x,n}}$$

and the question is whether $l^{-i+i}(x) = l(x)$ with R and $\bar{R}$ defined as they are.

Inserting eq. B.5 into eq. B.4,

$$\ln\left(\frac{l^{-i+i}_{x+n}}{l^{-i+i}_x}\right) = \bar{R}R\ln\left(\frac{l_{x+n}}{l_x}\right)$$

and, since

$$\bar{R}R = \frac{(M_{x,n} - M^i_{x,n}) + M^i_{x,n}}{M_{x,n} - M^i_{x,n}} \quad x \quad \frac{M_{x,n} - M^i_{x,n}}{M_{x,n}} = 1 \quad ,$$

$l^{-i+i}(x) = l(x)$, which shows that causes of death van be added using the same procedure as deleting them from the life table.

Cause-decreased Life Tables

The cause-decreased life table is almost identical to the cause-deleted life table. The cause of death i is divided into two parts, $i-$ which is the portion of deaths which are avoided, and $i+$ which is the deaths which still occur. The avoided deaths are now treated as a cause of their own, and this "cause" is deleted from the life table in precisely the same manner as following Keyfitz above.

Appendix C: Cohort-component Method of Migration and Fertility Estimation

Migration

This method of migration estimation can be used in the situations where relatively reliable data on population age-structure (census years), age-specific mortality, and age-specific fertility or total births exist, but data on migration is scant or unreliable. This situation is not rare. Migration is difficult to classify as it is not an unequivocal event such as birth, death, marriage, or divorce (see, e.g., Courgeau, 1988; Wils, 1993:1–8). Even if precise data on population exist – which commonly they do not – it is not certain when that movement should count as migration: after 6 months? after one year? after renting a house? obtaining a job?

To begin the estimation, take a population age vector in time 0, equal to $\overline{P_0}$. Pre-multiplication with the ordinary Leslie matrix (see, e.g., Keyfitz, 1985:201–35) containing age-specific birth and mortality probabilities only provides the population $\overline{P_t^L}$, which is what the age-vector of the population would be at time t at prevailing birth and mortality rates but *without migration, including the effect of migration in reducing or increasing births.*

To obtain the migration effect estimate, $\overline{P_t^L}$ is subtracted from the actual (census or survey) population, $\overline{P_t}$.

But say the purpose was to estimate migration only, *without* including the effect of migration on births. In this case, use of the fertility rate is replaced by using absolute, registered births, B. Using absolute births in the population projection provides the historically correct number of babies being born, while it still allows for the historically incorrect (because migration is excluded) number of women in child-bearing ages. The adapted Leslie matrix and the population vector can be written as:

$$L_t^* \times \overline{P_t^*} = \overline{P_{t+n}^*}$$

$$\begin{pmatrix} 1 & 0 & 0 & 0 & \dots & 0 \\ \frac{{}_5L_0}{2}B & 0 & 0 & 0 & \dots & 0 \\ 0 & \frac{{}_5L_5}{{}_5L_0} & 0 & 0 & \dots & 0 \\ 0 & 0 & \frac{{}_5L_{10}}{{}_5L_5} & 0 & \dots & 0 \\ \dots & \dots & \dots & \dots & \dots & \dots \\ \dots & \dots & \dots & \dots & \dots & 0 \end{pmatrix} \times \begin{pmatrix} 1 \\ {}_5P_0 \\ {}_5P_5 \\ {}_5P_{10} \\ \dots \\ \dots \end{pmatrix},$$

and the population is all units of the of the $\overline{P_t^*}$ vector except the first unit.

Migration is equal to the difference between the projected population $\overline{P_{t+n}^*}$ and the actual population $\overline{P_{t+n}}$:

$$\overline{M_{t \to t+n}} = \overline{P_{t+n}} - \overline{P_{t+n}^*}$$

If the projection interval is longer than one projection period, the vector M shows cumulative migration including the aging of migrants who came or left in earlier periods. A second procedure, to estimate the distribution of migration over multiple projection steps, is required.

Without further information about migration, e.g., the relative migration per period, or the migration age-structure, it is not possible to tell whether $\overline{M_{t \to t+n}}$ was spread evenly over the interval, or occurred just previous to $t + n$, or any other pattern.

To solve this, an age-distribution is assumed constant for all the periods in the interval, and given by the vector $\bar{m}$. The age-distribution can be a model migration age-distribution such as suggested by Castro and Rogers (1984). Total annual migration, M, is found using a heuristic trial and error method, which makes use of available empirical information if any is available. The assumed migration per period is added to the projected population at the end of each period (migrants thus experience no mortality in the period they move. For the young adults who make up the bulk of migrants, this is nearly true). The projected population is then:

$$\begin{matrix} 1 & 0 & 0 & 0 & \ldots & 0 \\ \frac{_5L_0}{2}B & 0 & 0 & 0 & \ldots & 0 \\ 0 & \frac{_5L_5}{_5L_0} & 0 & 0 & \ldots & 0 \\ 0 & 0 & \frac{_5L_{10}}{_5L_5} & 0 & \ldots & 0 \\ \ldots & \ldots & \ldots & \ldots & \ldots & \ldots \\ \ldots & \ldots & \ldots & \ldots & \ldots & 0 \end{matrix} \times \begin{matrix} 1 \\ _5P_0 \\ _5P_5 \\ _5P_{10} \\ \ldots \\ \ldots \end{matrix} + \begin{matrix} 1 \\ _5m_0 \\ _5m_5 \\ _5m_{10} \\ \ldots \\ \ldots \end{matrix} \times M = \begin{matrix} 1 \\ _5P_0^{*m} \\ _5P_5^{*m} \\ _5P_{10}^{*m} \\ \ldots \\ \ldots \end{matrix}$$

and the difference between the population vector $\overline{P_{t+n}^{*m}}$ and the actual population vector $\overline{P_{t+n}}$ is zero or close to zero.

Fertility

So far, in the estimation, a data situation has been assumed where the information on total births is better than that of age-specific fertility rates. This situation may be common in countries which do not have good population registration. In those countries, births may be fairly accurately registered – particularly if one-time vaccines are given, and mothers take their infants to a clinic at least once, but do not otherwise have great motivation to register. Then, good information may be collected on the number of births and perhaps also on the age of the mothers. However, the total population of women in each age may remain unknown or uncertain because of unregistered migration. Without the total women as the denominator, it is not possible to make a correct assessment of age-specific fertility rates. This appears to have been the case on Cape Verde.

When this occurs, the above estimation of migration in a multi-period interval using absolute number of births, can provide the basis for an estimate of the population between the beginning and the end year of the interval. With the migration estimation of the population vector, and the absolute number of births, plus an estimate of the age-distribution of births, an estimate can be made of the age-specific fertility rates and hence, the total fertility rate. For the age-distribution of births, the Coale and Hoover (1974) fertility curves can be used. An assumption has to be made about the extent to which fertility is controlled. In the case of Cape Verde, age-specific fertility estimations from official sources were used. These official curves were scaled up or down to obtain the registered number of births with the estimated population. The correction factor, c, was obtained with the following equation:

$$off_{10} \;\; off_{15} \ldots\ldots \times \begin{matrix} P_{10}^f \\ P_{15}^f \\ \ldots \\ \ldots \end{matrix} \times \frac{1}{B} = \frac{1}{c}$$

where off_x is the officially registered female fertility rate in age x to $x+n$, B is the absolute number of births, and c is the correction factor. The correction factor was applied to *off* to obtain the estimated age-specific fertility rates.

Appendix D: Coale and Trussel Method for Calculating Fertility Control, Adapted by Lutz, and Applied to Cape Verde

Coale and Trussel are concerned with marital fertility, because, they say, total fertility is determined by the nuptiality patterns in a population and the fertility within marriage. They go on to say that

> Marital fertility either follows natural fertility (if deliberate birth control is not practiced), or departs from natural fertility in a way that increases with age according to a typical pattern. In a population in which fertility is voluntarily controlled, the ratio of marital fertility at each age, r(a), to a schedule of natural fertility, n(a), is given by:
>
> $r(a)/n(a) = M \exp(m.v(a))$
>
> ... [where] $v(a)$ expresses the tendency for older women in populations practicing contraception or abortion to effect particularly large reductions of fertility below the natural level. [Coale and Trussel, 1976:187–188]

and M is simply a scale factor.

Coale and Trussel estimated the following values for v(a) and n(a) shown in *Table D.1.*

Table D.1. Values for $v(a)$ and $n(a)$ for seven age-groups of mothers calculated by Coale and Trussel. Source: Coale and Trussel, 1974:188.

	20–24	25–29	30–34	35–39	40–44	45–49
$n(a)$	.460	.431	.396	.321	.167	.024
$v(a)$	.000	–.316	–.814	–1.048	–1.424	–1.667

Note that $v(a)$ increases with age. In other words, this method is less appropriate when there is a cohort effect of controlled fertility – say among young women with a higher average level of education, or other new values. But perhaps cohort effects are rarer and less pronounced than the period effects measured by Coale and Trussel. This disadvantage can be canceled out by calculating small m for separately for every age group.

The formula applies to marital fertility because marriage rates are to important to total fertility. It does not allow for the consideration of marriage itself as a way to control fertility. It is, however, believed that many people who did not have access to modern contraception controlled their fertility with taboos and rules concerning marriage (see, for example; Norberg-Hodge on Ladakh or Abernethy, 1993).

Unfortunately, marital fertility is not a good approximation of fertility on Cape Verde because 40 percent of the births are illegitimate, according to the pregnancy rates of the 1988 *Inquerito sobre a fecundidade em Cabo Verde* (DGP, 1989). The non-marital pregnancies in that survey are 65 percent of all pregnancies in the age groups 15–19 and 20–24; 23 percent of all pregnancies at age 25–29; 16 percent at age 30–34; and 6 percent of pregnancies at 35–39. The decrease reflects the decreasing proportions of women non-married with increasing age.

Lutz (1987) suggests an adaptation to the Coale and Trussel model, which needs only data on total fertility rather than on marital fertility. He suggested this model for the case where only total fertility data was available, but it also applies in the case where marital fertility reflects significantly less than all births. This model is used to approximate the level of fertility control in Cape Verde throughout the decades from 1960–1990.

The Lutz model uses only fertility rates above the age of 30. Two assumptions must be made. "First, we have to assume that the percentage of illegitimate births is constant above age 30, and secondly that the age-specific proportions married above age 30 are constant" (Lutz, 1987:49). The assumption of constant proportions married above age 30 can be verified at least for the sample population of the 1988 survey: the proportions married were 82 percent at 30–34;

Table D.2. Measures of fertility control m* in Cape Verde 1960–1990, estimated with adapted Coale-Trussel model following Lutz.

				1990	
Age	1960	1970	1980	with secondary education	with primary education
35–39	−0.042	−0.038	−0.009	0.277	0.014
40–44	0.016	−0.029	0.004	0.071	0.021
45–49	−0.143	−0.189	−0.091	1.734	−0.086

90 at 35–39; 91 at 40–44 and 45–49. The illegitimacy rates cannot be verified because the sample numbers are unfortunately too small. They are assumed constant.

The measure of fertility control, called m^* by Lutz, is exactly the same as the Coale-Trussel formula, but replacing marital fertility $r(a)$ with total fertility $f(a)$.

$$f(a)/n(a) = M^* e^{m^* \cdot v(a)}$$

The taking the log on both sides of the equation gives:

$$\log(f(a)/n(a)) = log M^* + m^* \cdot v(a) \quad .$$

Given $f(a)$, $n(a)$, and $v(a)$, M^* and m^* can be solved as a simple regression problem. Say M is the ratio of $f(a)$ to $n(a)$ at age 30. If one is *am* interested in the age-specific values of small m, to see if the values for m are the same over each age-group, m can be calculated for each age separately by:

$$m(a) = log[(f(a)/n(a)^*(f(30)/n(30))]/v(a) \quad .$$

If the values for $m(a)$ are a relatively flat curve over the three age groups, it can be averaged to a total small m which indicates the level of fertility control in that population.

Table D.2 shows the values of M^* and m^* for total Cape Verde fertility in 1960, 1970, and 1980, while separating two educational groups in 1990.

The table shows that the values for m are practically zero in 1960, 1970 and 1980, in spite different levels of fertility. A value of m that is not zero should not be regarded as an indication of fertility control. Lutz (1987:46) suggests that using the original Coale-Trussel model values of m below .20 should be regarded as natural fertility, and for the truncated version used here, he suggests that levels up to .50 should be considered natural (*idem*:49). The results show that only the women with secondary education in 1990 may have controlled their fertility according to this calculation method.