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Population-Development-Environment in Mozambique Background Readings

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Contents

Foreword

After decades of war, Mozambique emerged as one of the poorest countries in the world. The countryside was riddled with mines and saddled with debt, high illiteracy and low life expectancy. It caught the attention of the world in 1992 when the two belligerent sides signed a lasting peace agreement. It has continued to hold the attention because of its remarkable recovery. Although growth declined in the first years of the new millennium, partly due to severe flooding, it remains positive nonetheless. To some, Mozambique is an example of a country locked in poverty; to others, it is a sign of hope.

It caught the attention of a group of researchers at IIASA, dedicated to the scientific analysis and better understanding of the relationship between population change and environmental factors, as an example of a country where much can be learned about these relationships. The Mozambique study is one of three African country studies, including Botswana and Namibia, and is the sixth in a series of such studies undertaken at IIASA (earlier studies include Mauritius, Cape Verde, and the Yucatan peninsula).

Many governments, organized as they are in separate ministries, try to tackle the problem of development in a compartmentalized way. And indeed, there is strength in this specialization. The real world, however, is not separated into distinct boxes; population, development, and the environment are interwoven. These relationships become particularly important in the long-term. Therefore, it is imperative, when looking at a long planning horizon, to regard the system as a whole. That is what the population-development-environment studies at IIASA undertake.

IIASA was most fortunate to find excellent and dedicated colleagues in Mozambique, who work in the same, integrated manner. They actively participated in the formulation of the study's research questions, design of the simulation model and the future scenarios. The Instituto Nacional de Estatística (INE) served as IIASA's main partner and local coordinator. The interaction produced valuable insights for Mozambican scientists and policy makers. Each paper in this report is a valuable contribution to the field, and together, they are an interesting compilation on socio-demographic dynamics, development and natural resource use in Mozambique, and constitute background research for a forthcoming scientific book entitled *AIDS, Education, and Sustainable Development: The Story from Mozambique* by Annababette Wils and Manuel da Costa Gaspar.

Wolfgang Lutz
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July 2002

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The research team from Mozambique consisted of Manuel da Costa Gaspar, Maimuna Ibraimo, and Emídio Sebastião. Members of the IIASA team were Vania Ceccato, Molly Hellmuth, Wolfgang Lutz (Project Leader), Isolde Prommer, Kuberin Packirisamy, Warren Sanderson, Ken Strzepek, Annababette Wils, and David Yates.

Institutions in Mozambique which contributed data or information to the project include the Ministry of Planning and Finance, the Ministry of Education, the Ministry of Health, the Ministry of Agriculture and Fisheries, the Ministry for Environmental Action Coordination, and the Ministry of Water Resources.

This project could not have been done without the help of many persons in Mozambique, who generously shared their information and data with us. In particular, we would like to acknowledge the help of João Loureiro at the Instituto Nacional de Estatística, Avertino Barreto and António Noya from the Ministry of Health, Virgílio Juvane and Ilídio Buduia from the Ministry of Education, Victória da Conceição Ginja from the Ministry of Planning and Finance. We would also like to thank Mafaldo Duarte at the Ministry of Education and Tomás Bernardo at the Instituto Nacional de Estatística, as well as the many technicians, who provided us with special tabulations and reports.

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Dr. Wils received her PhD in statistics and demography from the University of Vienna in 1995. In addition to her current position as visiting scholar at Tellus Institute in Boston, USA, she is coordinator of the Population and Environment Research Network (www.populationenvironmentresearch.org) and country coordinator of the Mozambique PDE Project conducted at IIASA. With Manuel da Costa Gaspar, she co-authored the forthcoming book on "AIDS, Education and Sustainable Development: The Story from Mozambique." She has authored many papers in her main areas of research, the demography of education, interactions between population and environment, and systems modeling, as well as on other demographic and environmental topics. Prior to joining Tellus Institute, she worked as a researcher at IIASA, at the Massachusetts Institute of Technology, and at Vassar College.

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List of Acronyms and Technical Notes

AIDS – Acquired Immune Deficiency Syndrome; the last and most severe stage of the clinical spectrum of HIV-related diseases

ARC – Annual runoff coefficient = Average annual runoff/average annual rainfall

CNP – Comissão Nacional do Plano (National Planning Commission), Maputo

CPI – Consumer price index

CUI – Cropland Use Intensity; a geographic parameter that represents an estimate of the amount of land under cultivation for a given area (or map or polygon).

DHS – Demographic and Health Survey

EIU – Economist Intelligence Unit

FAO – Food and Agriculture Organisation of the United Nations

FEWS – USAID's Famine Early Warning System

FSTAU – Food Security Technical Unit, SADC, Harare, Zimbabwe

GCM – Global circulation model

GDP – Gross domestic product

GIEWS – Global Information and Early Warning System on Food and Agriculture

GRDC – Global Runoff Data Centre, Federal Institute of Hydrology, Koblenz, Germany

Ha – Hectare

HIV – Human Immunodeficiency Virus; a retrovirus that damages the human immune system thus permitting opportunistic infections to cause eventually fatal diseases. The causal agent for AIDS

IIASA – International Institute for Applied Systems Analysis, Laxenburg, Austria

IEI – Industrial, energy and institutional water demands

IMF – International Monetary Fund

INE – Instituto Nacional de Estatística (National Institute of Statistics), Maputo

MAP – Ministério da Agricultura e Pescas (Ministry of Agriculture and Fisheries), Republic of Mozambique

MCM/a – Million cubic meters per annum

MINED – Ministério da Educação (Ministry of Education), Republic of Mozambique

MISAU – Ministério da Saúde (Ministry of Health), Republic of Mozambique

MPF – Ministério do Plano e Finanças (Ministry of Planning and Finance), Republic of Mozambique

Mt – Metric tons

NDVI – Normalized Difference Vegetation Index. This is calculated from the reflected solar radiation in the near-infrared (NIR) and red (RED) wavelength bands via the algorithm: VI = (NIR - RED)/(NIR + RED). The NDVI is a nonlinear function, which varies between -1 and +1 but is undefined when RED and NIR are zero. NDVI values vary with absorption of red light by plant chlorophyll and the reflection of infrared radiation by water-filled leaf cells. It is correlated with Intercepted Photo-synthetically Active Radiation (IPAR). In most cases (but not all) IPAR and hence NDVI is correlated with photosynthesis. Because photosynthesis occurs in the green parts of plant material the NDVI is normally used to estimate green vegetation. Water is shown gray; areas affected by cloud are masked white. The NDVI is highly correlated to surface vegetation.

NGO – Non-governmental organization

PDE – Population-development-environment

PET – Potential evapotranspiration

RENAMO – Resistência Nacional Moçambicana (Mozambique National Resistance)

SADC – Southern African Development Community

SER – Socioecological region

UNDP – United Nations Development Programme

UNEP/GRID – United Nations Environment Programme/Global Resource Information Database

UNESCO – United Nations Educational, Scientific and Cultural Organisation

UNHCR – United Nations High Commissioner for Refugees

UNICEF – Children's Fund (formerly United Nations International Children's Emergency Fund)

USAID – United States Agency for International Development

USGS – United States Geological Survey

WFP – World Food Programme of the United Nations

INTRODUCTION

Annababette Wils

The papers in this report focus on one environmental and two major population-related development challenges facing Mozambique today: the HIV/AIDS epidemic, low education levels among the labor force, and the provision of adequate water supplies. The health and skills of the labor force are two significant determinants of how much and what is produced by individuals and in the country as a whole, including agricultural and industrial products and services. Water is one of the most essential resources for basic economic production and human health. HIV/AIDS has emerged quite suddenly in recent years, and according to the most recent estimate, the HIV prevalence rate among adults aged 15-49 is 13.5%. It is the leading cause of death among young, able adults of working and parenting age. In 1999, 68,000 people died of AIDS.

The first paper, by Manuel da Costa Gaspar, gives a historical review of the general demographic trends in Mozambique. It describes population growth, distribution, fertility and mortality, including AIDS from 1960-1997. There is very little reliable data available from this period, as the author discusses, due to severe disturbances in the country including two long wars and upheaval at the end of the colonial period. He does an admirable job of pasting together what information exists into a comprehensive demographic review of the past four decades in Mozambique.

In the second paper by Manuel da Costa Gaspar, he presents the multi-state population model for HIV/AIDS and discusses nine future scenarios that focus mainly on HIV/AIDS uncertainties and policy interventions. The scenarios include alternative assumptions about how fast the epidemic will spread in the absence of policy interventions. More importantly, they include alternative assumptions about behavioral change and the administration of drugs to prolong the life of HIV/AIDS patients. The scenarios clearly show the positive impact of behavioral change to reduce new HIV infection rates.

Low levels of education are another challenge to development, mainly because education imparts necessary skills to participate in any sector of a modernizing economy. A history of colonial neglect and civil war left Mozambique with a poorly developed school infrastructure and a 61% illiteracy rate among adults over 15, according to the 1997 population census. Two papers look at education, one on school enrollment, and the second on the skilled labor force.

The paper by Annababette Wils and Manuel da Costa Gaspar shows that children who enter school before the age of 8 have much lower drop out rates than older entrants, and can expect to finish almost 7 grades. Children who enter school at older ages remain in school a shorter time, from 2-5 grades, depending on the age of entry. The paper uses specially prepared tabulations from the Ministry of Education and the 1997 population census, and an adapted form of the cohort reconstruction method used by UNESCO to calculate expected years of schooling.

Up to now, little was known about the skilled labor force in Mozambique, beyond basic numbers such as how many people in the labor force have secondary and tertiary education degrees. The paper by Maimuna Ibraimo gives an invaluable description with unprecedented details on the characteristics of the highly skilled labor force in Mozambique, including age, sex, and location of employment, and suggests possible trends in a future with HIV/AIDS. It also estimates some of the direct costs of the small number of skilled workers to the government. Finally, it presents seven scenarios for the future of the size of the skilled labor force, and economic impacts thereof, particularly with regards to future losses from AIDS deaths. The paper shows that even with AIDS, the size of the skilled labor force will grow appreciably in the next two decades because of recent and projected increases in school enrollment.

Isolde Prommer looks at the agriculture sector, which is strongly affected by population distribution and health, particularly deaths from AIDS. The paper provides an overview, including factors that determine output, such as climate, soil and terrain conditions, and labor availability. It includes a detailed description of crop and livestock production by province and an analysis that explains the existing patterns. It looks at the uneven sex ratios in agriculture – women are dominant – by province. The paper proposes that the effects of labor losses due to AIDS might be similar to those experienced by farming systems with a shortage of male labor. It closes with a general framework for looking at the impact of HIV/AIDS on the agriculture sector.

Mozambique is a country plagued by water problems. Regular, severe flooding and drought affect large numbers of people. The irregular weather patterns compound the difficulties of supplying sufficient water to urban centers with weak hydrological infrastructure. Climate change in the next decades will not improve matters. Molly Hellmuth, Kenneth Strzepek and David Yates look at this important issue in the final paper and present in detail the water model used for Mozambique, as well as the river basins and the hydrological balance it reproduces. It is the most detailed and dynamic model of water balance in Mozambique today, providing information per major basin on a monthly projection basis, and could doubtlessly find application in other projects more specifically focused on water issues. The paper also presents a case study of Maputo City, the country's capital and economic center. With its present infrastructure, the city is almost sure to experience severe water shortages within the next ten years, mainly due to increased water demand from residential use and industry.

In addition to this report, the project has also produced a number of other publications and a simulation model. The PDE simulation model for Mozambique was developed to make future scenarios for the country. These scenarios allow policy makers to test policy measures affecting HIV/AIDS, education, investment, and many other leverage points. There were two workshops held at IIASA and one in Maputo to train researchers and policy makers in the use of the model. Today, the model is being used at the Instituto Nacional de Estatística to produce population projections with AIDS. The model is available free of charge from IIASA's Web site (www.iiasa.ac.at/Research/POP/pde/).

A summary of the project's main findings and policy recommendations was published in the Executive Report "Mozambique's Future: Modeling Population and Sustainable Development Challenges" (also available on the IIASA Web site). A major book with more detailed findings, tentatively titled *AIDS, Education, and Sustainable Development: The Story from Mozambique*, is currently being drafted by Annababette Wils and Manuel da Costa Gaspar. Finally, study results have been presented at multiple international conferences and a number of journal articles are under review or in preparation.[1]

[1] For more information about any of these outputs, please contact Manuel da Costa Gaspar (gaspar@ine.gov.mz), Annababette Wils (awils@tellus.org), or Isolde Prommer (prommer@iiasa.ac.at).

POPULATION SIZE, DISTRIBUTION, AND MORTALITY IN MOZAMBIQUE, 1960-1997

Manuel da Costa Gaspar

Introduction

We can only understand Mozambique's population dynamics in the context of history, including the colonial era, three decades of war (1964-1992), and the vast transformations that have taken place since independence in 1975. The effects of the past events are reflected in a low level of development, even when compared with other East-African countries, with high mortality, fertility, and illiteracy rates. According to the results of the Second General Population Census in 1997 (Instituto Nacional de Estatística 1999), for example, adult illiteracy and infant mortality were among the highest rates in the world, 61% and 146 per 1,000 live births, respectively. The country also has one of the world's lowest population densities: 20 inhabitants per square kilometer.

Another example of the influence of history on demographic changes can be seen in migration flows. The refugee movements caused by the armed conflicts have had a profound effect on the process of urbanization; population growth rates and other demographic characteristics. The 16 years of civil strife in Mozambique caused an estimated 4.7 million internal and external refugees. Between 1993 and 1995, 1.7 million refugees returned from abroad, and 3 million internally displaced people returned home, most of them to central areas of the country. The majority of refugees from abroad came from Malawi (75%), from Zimbabwe (14.5%), and the remaining 10% from South Africa, Tanzania, Zambia, and Swaziland. All of these countries have very high HIV infection rates and commercial sex is common, and return migration might have driven the HIV infection rate up in Mozambique. Today, the HIV prevalence among adults is estimated to be 16%.

Given the low population density and an abundance of unused arable land, the main concern for Mozambique today, with regard to demographic processes, is not population size or density. Much more, demographic problems relate to the very young age structure of the population: high levels of fertility and mortality especially among the nation's poorest; as well as the uneven geographical distribution of people.[2] About 45% of all Mozambicans are younger than 15 years old; in other words, the youth dependency ratio is high. The socioeconomic implications of this situation with regards to the availability of medical and educational services will be discussed below. The total fertility rate is 5.9 and life expectancy is 42 years at birth,

[2] This stance is reflected in the National Population Policy recently approved by the government.

which puts Mozambique among the countries with the highest fertility rates and lowest life expectancy in the world.

Finally, about 70% of the population resides in the rural areas in scattered settlements, which makes it more difficult to provide basic services such as education, electricity, and clean water. Partly as a result, in the rural areas, the access to basic services is very limited; 72% of the population is illiterate; 96% of the houses do not have electricity and 92% do not have piped water. This low level of development in the rural areas could be conducive to a large flow of migrants to the cities, as well as continuing high levels of fertility and mortality.

This paper is an attempt to reconstruct four decades of demographic development in Mozambique, from 1960 to 1997. The basic sources of data are the population censuses of 1960, 1970 and 1980 and in particular the census of 1997, as well as the 1997 Demographic and Health Survey.

Source and Quality of Data

In Mozambique, the main source of data on the size, growth rate, and distribution of the population are the population censuses. These sources are sometimes complemented by demographic and health surveys. Data from civil registration sources are not considered adequate for a complete demographic analysis because of limited coverage and poor quality.

In spite of a long tradition of population counting, there is no coherent series of population censuses. The first population census occurred in 1928. From this first census, until 1960, blacks and whites were counted in separate years. The regulation of the Statistical Office approved in December 1924 foresaw two sets of census counts. In years ending with 0, only those who were *non-indigenous* would be counted, and years ending with 5 would concern the *indigenous* population. With regards to the *indigenous* population, one official, Santos Junior, said that the high levels of illiteracy, the extraordinary dispersion, and the inaccessibility of many areas rendered the results for those census counts highly dubious. Another official, Tenente M.A. Costa (1929), gave various examples of possible under-counting even in those places that were accessible. For example:

- How many women live in this house?
- Three, responds the inhabitant.
- But I see four!
- Yes, but that woman does not count; she is my mother.

The same question in another household:

- How many women live in this house?
- Five.
- But I have seen six!
- One of them is my brother-in-law.

Another example:

- How many children do you have?
- Four.
- But I see five…
- Oh, the little one is not a person; he is a baby.

From 1970 on, the whole population, black and white, was counted together. However, the lack of interest in the black population as well as the war of independence resulted in a very low coverage in that census. It is estimated that the 1960 and 1970 census counts omit roughly 13% of the population.

During the post-colonial period, two census counts were taken, in 1980 and 1997, each with high coverage (96.2% and 94.9%, respectively). A Demographic and Health Survey was also conducted in 1997 with the objective of collecting information about women's reproductive behavior, contraception and health practices. The response rate of the survey was higher than 95%.

Another problem with long time series is that the spatial units of the country have changed. The political-administrative boundaries differ from one census to the next. For example, between the 1960 and the 1970 censuses, the country was divided into 9 provinces with 88 *conselhos* and 100 districts. After independence, the country was reorganized. The district of Sofala-Manica was divided into two provinces, Sofala and Manica. The city of Lourenço Marques (called Maputo City today) was separated out as a province of its own, due to its economic and demographic importance and distinctiveness. After these changes, the 1980 census referred to 11 provinces (including Maputo City) and 106 districts. The search for an administrative division that would facilitate socioeconomic development led the government to make a further change in 1986. In that year, basically three districts that were formerly part of Maputo City were transferred to Maputo Province. After this and other small changes, the 1997 census counted 11 provinces and 133 districts (including 4 districts in Maputo City).

The situation described above limits the possibilities for a comparative analysis over time. However, we do provide a national analysis, and with reservations, an analysis on the provincial level. We exclude the district level. The district and provincial changes between 1960, 1970, 1980 and 1997, as well as the population by district for each of the four censuses are given in the Appendix and Appendix Tables A and B.

History of Population Size

Mozambique was the 13th largest African country in terms of population size in 1997, largely due to the expansive territory of the country (780,380 square kilometers). Population density in the country is one of the lowest in Africa. In 1997, it barely exceeded 20 persons per square kilometer.

In the early days of Portuguese colonialism, the most lucrative trade was slavery. Slave trade continued until the middle of the 19th century. For more than three centuries, thousands of Mozambicans were sold abroad. The demographic consequences are probably still visible today. Although we do not know exact numbers, estimates for 1780-1800 indicate between 10,000 and 15,000 persons were sold annually. From 1800-1850 the number increased to about 25,000 per year. Together, these numbers suggest that about 1.5 million people were forced to leave the country between 1780 and 1850. Numbers on total population in the 19th century do not exist, but in the early part of the 20th century, there were barely 4 million indigenous people in Mozambique (1928 census; Mitchell 1995). The implication is that the numbers of slaves exported in the preceding century were a significant portion of the population, and more often than not the young and the healthy.

Slavery had other repercussions as well. It significantly reduced the productive capacity of farmers. Additionally, farmers' food security was reduced through forced cultivation of commercial crops – cotton, cocoa and peanuts.

Parallel to the slave trade, and as a result of the relatively low capitalization of the Portuguese colony, men went to work abroad as laborers, in particular in Southern Rhodesia (now Zimbabwe) and South Africa. Wages in Rhodesia and South Africa were higher than in Mozambique and the working conditions were better, which resulted in considerable migration.

The data on labor migration are rare and not complete because of the nature of the migration. Most laborers to South Africa were recruited legally, through official agents, but most of the laborers to Rhodesia went illegally. It is clear that there was considerable interest on the part of the employers to recruit clandestine labor, as illegal workers can be paid lower wages and set in worse conditions.

Over the course of the years, various agreements were signed with South Africa and Rhodesia regarding Mozambican workers. The first accord was between Portugal and Rhodesia in 1913. The terms of the accord foresaw the recruitment of a maximum of 15,000 workers from Tete. The growth of the Rhodesian economy during World War II was reflected in an increase in the number of Mozambicans working there. It is estimated that by 1947, approximately 200,000 Mozambicans were under contract for Rhodesian companies, including the 15,000 workers from Tete (Adamo et al. 1981). With regards to workers in South Africa, the Center of African Studies in the Eduardo Mondlane University provides the following figures: 80,832 workers to South Africa in 1913; 96,300 in 1946; 106,500 in 1951; and 113,300 in 1970 (Adamo et al. 1981). For various reasons, the number of Mozambicans working in the mines of South Africa has declined recently. In 1999, it was estimated that the number was 73,097.

This long process of emigrant labor and slave exportation implies that marital unions were temporarily or permanently disrupted, resulting in an inevitable decline in fertility. Furthermore, some of those who went abroad and returned brought with them diseases that diffused to the rest of the population (Sequeira 1934).

Besides the mortality, which was directly linked to diseases, there was a prolonged period of drought from 1794-1802 in southern Africa, which resulted in reduced food production and many deaths. The effect of all the factors mentioned above is still visible in the distribution and low density of the population today.

Distribution, Growth, and Density, 1960-1997

As mentioned above, the census counts from 1960, 1970, 1980 and 1997 have different levels of sub-enumeration. In order to make the censuses comparable and to analyze the evolution of population growth, the Instituto Nacional de Estatística decided to adjust the population counts using various techniques and procedures, the discussion of which is outside the scope of this paper. The adjustments were applied to the total national population for all four census counts, and at the provincial level for the 1980 and 1997 censuses. The adjusted population by district is available from the author upon request.

Before we begin with the demographic analysis, it is important to explain that in Mozambique, as in many other countries, publications concerning census counts contain two population sums: the nominally-counted population and the adjusted population, which corrects for omissions in the census count. Table 1 shows nominal and adjusted population.

Table 1. Adjusted and nominal population in Mozambique, census counts 1960-1997. Sources: Gaspar (1989); Instituto Nacional de Estatística (1999).

Date of census	Population (millions)		Omission rate (%)
	Nominal	Adjusted	
September 15, 1960	6 603.7	7 595.3	13.3
September 15, 1970	8 168.9	9 407.7	13.4
August 1, 1980	11 673.7	12 130.0	3.8
August 1, 1997	15 278.3	16 099.3	5.1

The nominal population in 1960 and 1970 was 6,603,652 and 8,168,933 people, respectively. These results are quite far from the actual population number, because many areas of the country were not covered. The quality of the 1960 data was compromised by people's reluctance to participate in the census. The objectives of the census counts were associated with officials looking for forced labor and taxes, so people were hardly motivated to be counted. In 1970, in addition to these factors, the war of independence made it difficult to reach everyone.

In both cases, the quality of the data is deficient due the people's reluctance to participate in the census. On the other hand, the method used during the data collection allowed some degree of miscount. In fact, in some areas the population was concentrated for the enumeration. For these reasons, the nominal population count needs to be adjusted. In 1960 and 1970, the adjustment factor was 13%. For the 1980 and 1997 censuses, which have a much lower degree of omission, the counts also needed adjustment. In the rest of this analysis, we will use the adjusted population whenever possible.

Although it is difficult to give precise numbers concerning population for any time before 1980, we can identify a few general, consistent tendencies. Between 1960 and 1997, the population size more than doubled from 7.6 to 16.1 million, which corresponds to an average annual growth rate of 2%. The growth rate was not constant throughout the period. From 1960-1970, average population growth was 2.2%; it increased slightly to 2.5% annually from 1970-1980; and was lower (1.6%) from 1980-1997 (see Table 2). The atypical pattern in this time series, particularly with regard to the last interval, reflects the socioeconomic and political history of the country. In effect, the low population growth rate from 1980-1997 is directly related to the civil war and elevated mortality during that time, as well as emigration which was not compensated by returns after the Peace Agreement (Instituto Nacional de Estatística et al. 1998). It also results from a slight decline in fertility during that period.

Table 2 also shows the evolution of population density, which reflects the trends described above and is characterized by a gradual increase from 9.5 inhabitants per square kilometer in 1960, to 11.8 in 1970, 15.2 in 1980 and 20.1 in 1997. The population density of Mozambique is similar to that of Botswana, (26.3) and Namibia (18.7), but is very low compared to the majority of African countries in 1995, where the highest population density rates were around 68 inhabitants per square kilometer in Lesotho and 83 in Malawi.

Table 2. Adjusted population size at the time of the censuses in 1960, 1970, 1980, and 1997. Average annual population growth rate in census interval preceding census, density at time of census.

Year	Population (millions)	Growth rate (%)	Density (hab/km^2)
1960	7,595.3	-	9.5
1970	9,407.7	2.2	11.8
1980	12,130.0	2.5	15.2
1997	16,099.3	1.7	20.1

Heterogeneity Between Provinces

Before proceeding, we should clarify that the numbers in this section refer to the nominal population for 1960 and 1970, and to the adjusted population for 1980 and 1997. Also, the administrative units were not constant during the whole period. As mentioned above, at the time of the 1960 and 1970 censuses, the country consisted of 9 provinces. In 1975 Manica-Sofala was split into two provinces, Manica and Sofala, and Maputo was split into Maputo Province and Maputo City. Therefore, the 1980 and 1997 censuses count 11 provinces. In this context, the data have been split into two groups, 1960 and 1970, and 1980 and 1997.

As we can see from Figure 1 and Table 3, neither the distribution nor the growth rates of the population are uniform. In Figure 1, the provinces have been split into three groups of growth rates: high growth above 2% annually; medium growth of 1-2%; and low growth of less than 1% annually. Manica and Sofala are included in the 1960-1970 period as one province, which splits into two entities. Similarly, Maputo Province of 1960-1970 splits into Maputo Province and Maputo City of 1980-1997. We should note that there was a further reorganization of Maputo Province and Maputo City in 1986, which consisted of the return of Matola district to Maputo Province. The classification cannot reflect the exact growth rates of all provinces due to the high rates of omission in 1960 and 1970.

In the period from 1960 to 1997, there were shifts in the rate of population growth as well as in the hierarchy of provinces. In the period 1960-1970, Maputo Province, Inhambane, and Zambézia experienced high rates of growth, but all three had medium levels of growth from 1980-1997. In contrast, Cabo Delgado, Niassa, and Tete, which all had low population growth rates from 1960-1970, had shifted to high growth rates by 1980-1997. The provinces of Cabo Delgado, Niassa and Tete were all strongly affected by the war of independence. This suggests that the abrupt shift from low growth areas in the 1960s to high growth areas in the period 1980-1997 is due to a shift in census coverage as well as a reduction of mortality.

The case of Maputo Province and Maputo City is complicated by the fact that in 1986, Maputo City lost three districts to Maputo Province. These three districts basically comprise the city of Matola, which in 1997 had 425,000 inhabitants. An estimate of the population growth in the previous area of Maputo City would include Matola. In 1980, Maputo City had 739,000 inhabitants including people living in the districts that presently comprise Matola City. In 1997, there were 967,000 inhabitants in Maputo City and 425,000 in Matola City, a total of 1.391 million. The average annual population growth rate from 1980 to 1997 in the area comprising Maputo *and* Matola Cities was 6.3%.

Figure 1. Groupings of population growth rates by province and shifts of growth rates from the period 1960-1970 to 1980-1997.

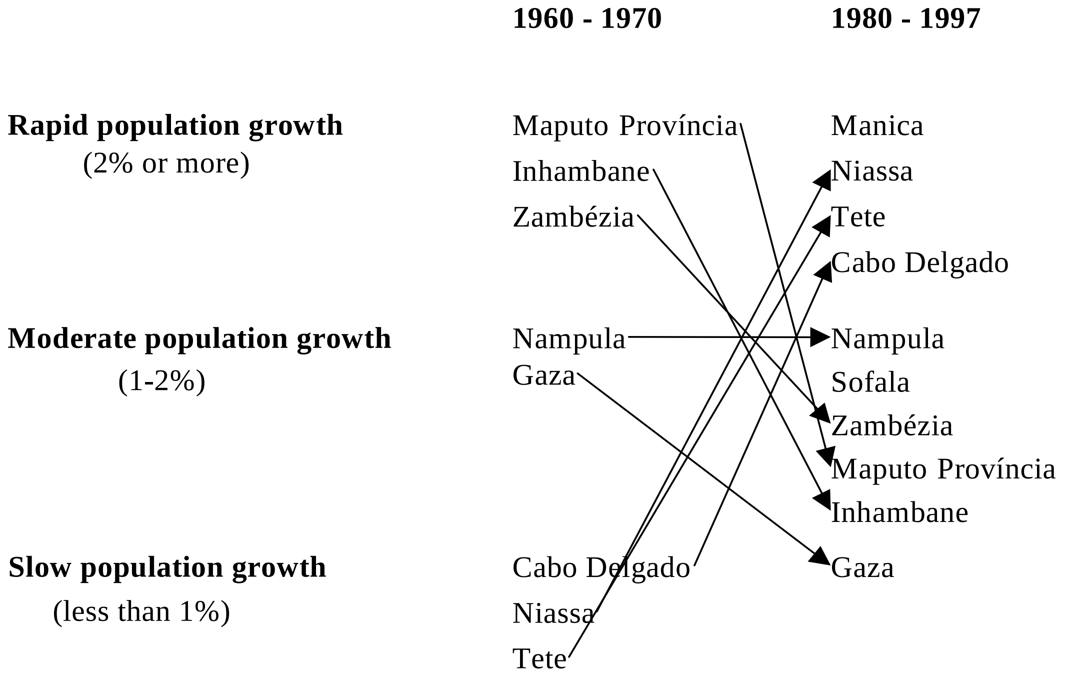
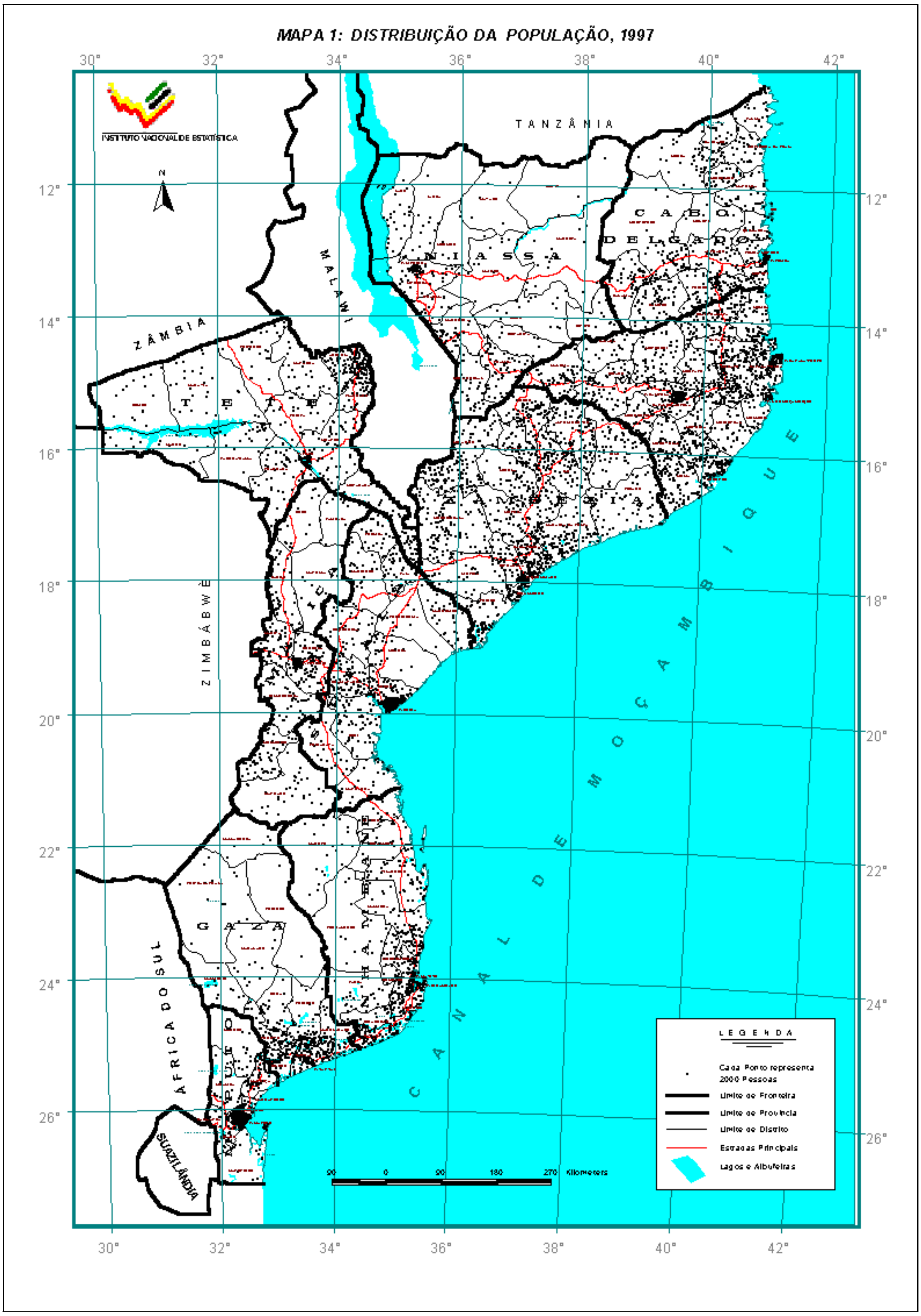


Table 3. Population and population growth rate, by provinces, 1960-1997.

	Population (millions)				Growth rate (%)	
Provinces	1960	1970	1980	1997	1960-70	1980-97
Total	6,603.7	8,169.0	12,130.0	16,099.2	2.2	1.7
Niassa	281.1	285.3	514.1	798.3	0.2	2.6
Cabo Delgado	548.6	546.1	940.0	1,361.7	-0.1	2.2
Nampula	1,452.4	1,716.5	2,402.7	3,139.3	1.7	1.6
Zambézia	1,368.7	1,747.9	2,500.2	3,060.5	2.5	1.2
Tete	471.4	488.7	831.0	1,211.0	0.4	2.2
Manica	779.8	1,079.7	641.2	1,026.8	3.3	2.8
Sofala[b]	(a)	(a)	1,065.2	1.354.1	(a)	1.4
Inhambane	583.1	748.6	997.6	1,186.6	2.5	1.0
Gaza	681.7	756.7	990.9	1,120.8	1.1	0.7
Maputo Province[c]	436.9	799.5	695.1	841.5	6.2	1.1
Maputo Cidade	(a)	(a)	552.0	998.6	(a)	3.6

(a) Did not exist as an independent province at the time of the 1960 and 1970 censuses.
(b) Refers to the area of what is presently Manica and Sofala provinces in 1960 and 1970
(c) Refers to the area of what is presently Maputo Province and Maputo City in 1960 and 1970.

Figure 2. Population distribution in Mozambique, 1997 census data. Source: Compiled by the Instituto Nacional de Estatística using data from the 1997 population census.



In the area of Maputo Province excluding Matola City, the population *declined* from 501,000 in 1980 to 382,000 in 1997, an average annual population loss of 2.7%. This high rate of population attrition is most certainly due to migration to Maputo City and to foreign countries. The population decline in this period is accompanied by a significant drop in the male to female sex ratio in the ages above 15 (see *índice de masculinidade* by province in the webpage www.ine.gov.mz).

Although shifts occurred in the population growth rates, in general, the rank of provinces with regards to population density remained stable during the whole period. In 1997, the provinces in order of density were: Maputo City (3,329 persons per square kilometer), Nampula (38.5), Maputo Province (32.3), Zambézia (28.9), Sofala (19.9), Gaza (14.8), Tete (12.0), and Niassa (6.2). Of the larger entities, the provinces of Nampula and Zambézia, located along the coast (see Figure 2) were and remain the most densely populated provincial regions by far. In 1997, 39% of the population lived in these two provinces alone. However, there were pockets of higher population density along the Zambezi river in Manica and Sofala, the border to Malawi in Tete, and the coastal regions of Inhambane and Gaza.

It should be noted that the distribution of the population is partly rooted in the colonial period when the region was incorporated into the global economy. This integration implied socioeconomic and political changes as well as shifts in the demographic mosaic of the country as migrants flowed to regions where the monetary economy was stronger. The result of this flux is seen in the concentration of people in coastal cities and in coastal regions where products were grown and processed for the Western markets.

The concentration of people along the coast could be a result of the Portuguese interest to occupy strategic points to maintain their national interests in Africa. We only need to remember that during the conference of Berlin, Portugal's stated interest to create a belt of colonies from Angola to Mozambique conflicted with England's aspirations to unite Africa under its flag from Egypt to the Cape. The Berlin Conference imposed more modest borders on both countries. During this conference the principle of the right of occupation, which maintains that a country has the right to the territory that it can defend, was given precedence over historical rights to a region emanating from discovery. The concentration of the population along the coast appears to have been an attempt to ward off coastal attacks.

Mortality and Life Expectancy, 1960-1997

As in most developing countries, the mortality estimates for Mozambique are based on population censuses and demographic and health surveys. The system of civil registration covers only a small portion of the country and the data collected are of limited interest to demographic studies.

During the period of our analysis (1960-1997) there were four censuses and two demographic and health surveys (1991 and 1997). The censuses include systematic questions, which allow us to estimate mortality using indirect estimation techniques. As with other information, the data concerning mortality contain irregularities, which vary over time.

There were some modifications to the census questionnaires over time that compromise the comparability of the data over time. In the censuses from 1940 to 1970 there was no direct reference to deaths. The questions referring to children were formulated as follows: "How many children have you had?” and “How many children have survived to today?” In the 1960 census, the former question erroneously included stillbirths, and so the results concerning children ever born and children surviving were not published. In the 1980 census, the latter question was changed to: “How many of your children have died?” which created some negative reactions because of the reference to deceased persons. This problem was corrected in the 1997 census and the two demographic and health surveys.

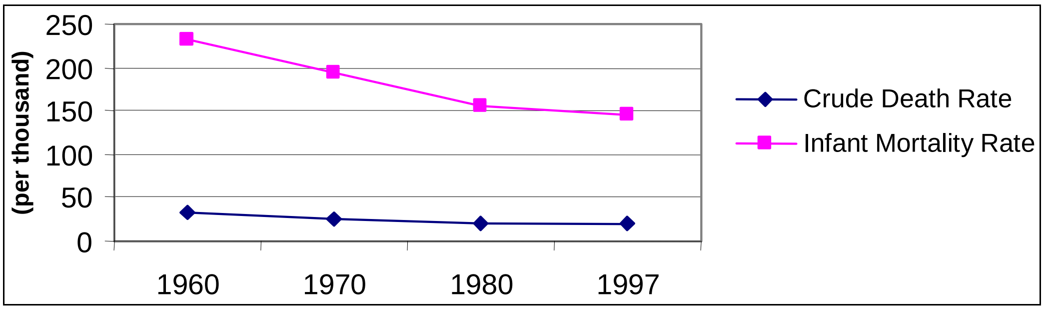
This paper does not include the mortality estimates from the 1991 demographic and health survey because the results are very biased due to the ongoing civil war. The results of that survey do not reflect the situation in the country as a whole, and exclude the most critically war-affected regions.

The estimates for the crude death rate and life expectancy at birth, using the census data are shown in Table 4 and Figure 3. It is clear that the mortality trends reflect the long periods of war and the adverse climate conditions that prevailed over the past four decades. The levels of mortality are consistently high, and corresponding life expectancy is low.

Table 4. Estimates of the crude death rate, infant mortality rate, and life expenctancy at the time of censuses from 1960-1997, both sexes. Sources: Unidade de População e Planificação (1993); Instituto Nacional de Estatística (1999).

Indicator	1960	1970	1980	1997
Crude death rate (per thousand)	31.9	25.7	20.5	21.2
Infant mortality rate (per thousand births)	231.0	193.0	156.1	145.7
Life expectancy at birth (in years)	33.8	38.7	43.5	42.3

Figure 3. Estimates of the crude death rate, infant mortality rate, at the time of censuses from 1960-1997, both sexes. Sources: Unidade de População e Planificação (1993); Instituto Nacional de Estatística (1999).



The crude death rate declined from 32 per 1,000 inhabitants in 1960 to 21 in the final period. Life expectancy was 34 in 1960 and increased to 42 in 1997, which is a modest achievement over 37 years. Neither trend – the decline of the crude death rate nor the rise in life expectancy – was constant over the whole period. During the war of independence and the civil war there were periods during which mortality increased, as we shall see below.

With regard to infant mortality, the 1997 census results indicate that 146 infants died before their first birthday, out of every 1,000 births. According to the Demographic and Health Survey of the same year, the number was 135. According to the UNICEF report on infant mortality for the year 2000, Mozambique is among the countries with the highest infant mortality rate, followed only by Sierra Leone (182), Angola (170), Niger (1966), Afghanistan (165) and Liberia (157).

Two types of information on infant mortality are the censuses and the Demographic Health Surveys. The data from these sources indicate the same *trends* for infant mortality, although the infant mortality rate calculated with the census is about 10-15 percent higher.

The Demographic and Health Survey of 1997 included retrospective questions on fertility and infant mortality. With regards to infant mortality, the Survey collected information on births from every woman aged 15-49, specifically, the number of children born, and the number died, and the age at which the child died. This information allows us to estimate neo-natal, infant, and under 5 mortality over 25 years. These estimates, together with the census estimates from 1960-1997, are shown in Table 5.

Compared to general mortality, infant mortality is very responsive to health and development programs. In the late colonial period of economic growth, from 1960-1970, infant mortality fell from 231 to 193. During the early years of independence, the government initiated various programs related to education and health. In the area of health, for example, national vaccination campaigns were introduced in 1976, along with regular programs to combat infectious diseases and to promote infant and maternal health. As a result, infant mortality dropped from around 175 at independence to 156 in 1980. It should be noted that the decline in infant mortality during these five years occurred in a period when the gross domestic product dropped sharply and therefore must have been largely attributable to social programs. Unfortunately, the mortality decline was interrupted in later years by the growing armed struggle and other adverse factors.

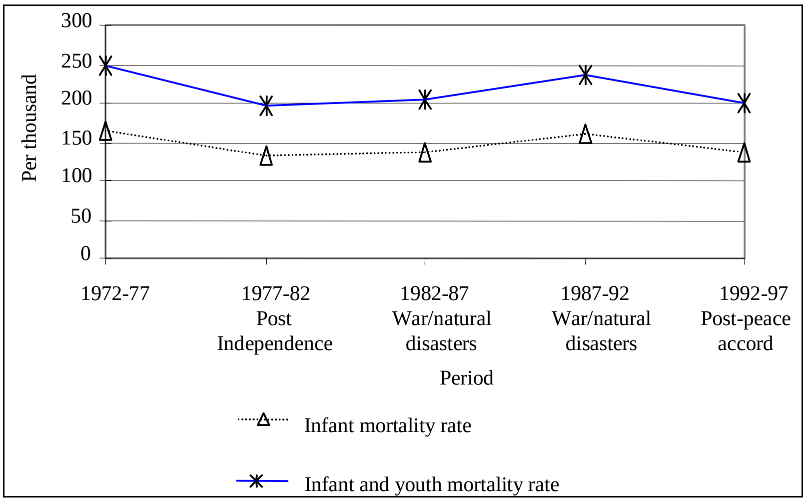
Estimates of infant mortality trends during the 1980-1997 intercensal period are diverse and sometimes contradictory, partly because no census was possible in 1990 due to the war. The National Demographic Survey conducted in 1991 was compromised by limited coverage in insecure areas, so its results do not necessarily reflect trends in the whole country. As a result, the only source of data concerning mortality in this period is the retrospective information from the 1997 Demographic and Health Survey. Table 5 shows the estimates of infant mortality in five-year periods from 1972 to 1997 using the DHS data.

Table 5. Youth mortality rates, infant mortality rates, and combined youth and infant mortality rates for the period 1960-1997. Sources: Unidade de População e Planificação (1993); Instituto Nacional de Estatística (1999); Instituto Nacional de Estatística et al. (1998).

Indicator (per thousand)	1960	1970	1972-1977	1980	1977-1982	1982-1987	1987-1992	1992-1997	1997
Infant mortality rate (census counts) (per thousand)	231	193		156					146
Infant mortality rate (DHS 1997) (per thousand deaths)			164		133	136	161	135	
Infant and youth mortality rate (DHS 1997) (per thousand)			250		195	204	238	201	

The infant and under-5 mortality trends that emerge from the DHS are consistent with what we know about the socioeconomic situation in Mozambique. In Figure 4 we note three distinct periods. The first period, from 1972-77 to 1977-82, which includes the first years of independence, shows a decline in mortality as a result of the new health policies introduced by the government, including free services, hospitalization and medical consultations. This positive tendency was reversed in the second period from 1982-87 to 1987-92, which includes the most devastating years of the war and corresponds to a few other climate disasters, which raised mortality and lowered the welfare of the people. By the end of this period, infant and under-5 mortality levels had returned to their 1972-77 values. During the third period, which includes the five-year period 1992-97, mortality declines once more, following the General Peace Agreement in 1992, and the return of a stable political situation, national reconstruction, return of the refugee population to their homes, and the new development programs. It is to be hoped, with continued peace, that the recent trend will continue, so that after 25 years of stagnation, the mortality rates in Mozambique might begin a sustained decline.

Figure 4. Infant and infant plus youth mortality rate, 1972-1997. Source: Demographic and Health Survey 1997.

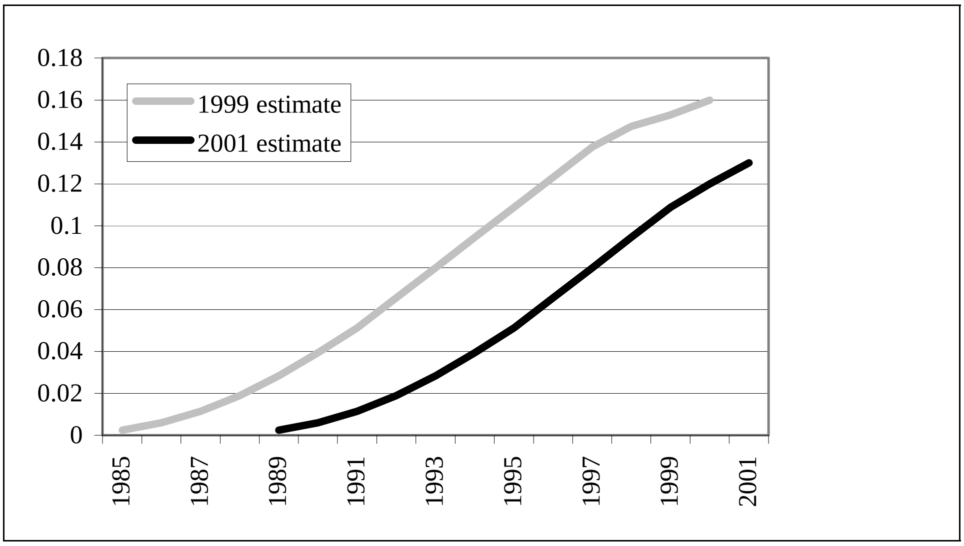


However, the future of mortality and life expectancy is uncertain due to the expansion of the HIV/AIDS epidemic. According to the data available, the HIV infection rate among adults aged 15-49 was 16% in 2000. The rise in HIV/AIDS, especially among young adults and women, constitutes one of the primary preoccupations of the government today. Of the people who were infected in 2000, it is estimated that 71.9% of the AIDS cases and 84.3% of HIV was in the age group 15-49. Unprotected heterosexual relations are the primary cause of HIV transmission in Mozambique. Prevalence is higher among men in the age groups above 20, and is higher among women in the age group 15-19, which indicates that young women are infected through relationships with men older than they. By 2000, it was estimated that 340,000 children were AIDS orphans and 162,000 orphans from other causes of death. If there is no intervention, the epidemic, in which the sexually-active population is affected, is likely to expand.

The infection of HIV has spread rapidly since the 1980s, as shown in Figure 5. There are two lines in the figure, the higher gray one based on estimates from 1999, and the lower black one revised as new data was collected from a larger number of sentinel sites in late 2001. HIV prevalence increased drastically in the 1990s when, following the Peace Agreement, refugees and internally-displaced people returned to their homes. The majority of infections occur in areas of the country where there was a massive influx of refugees following the Peace Agreement. It is estimated that the war resulted in 1.7 million refugees outside the country, and that one-third of the population was internally displaced. After the signing of the Peace Agreement in 1992, there was a massive return of refugees from neighboring countries where the levels of HIV/AIDS were much higher than in Mozambique. The majority of refugees returned from Malawi (75%), from Zimbabwe (14.5%), and the remaining 10% from South Africa, Tanzania, Zambia, and Swaziland. All of these countries have very high HIV infection rates and commercial sex is common. Around 83% of these refugees returned to the center of the country; 12% to the north, and 5% to the southern provinces. The HIV infection rate is presently highest in the central provinces.

As the Strategic Plan to Combat Sexually Transmitted Diseases, which was approved by the government in 2000, states, this situation requires the adoption of urgent popular measures of education and advocacy to reduce poverty, increase prevention.

Figure 5. Estimated HIV prevalence rates among adults aged 15-49 from 1985-2001.



Conclusions

In Mozambique, the question of demography constitutes an important aspect of policy formulation and social and economic programs. The economic structures adopted in the past few decades, as well as various development strategies and political factors, influenced the structure of the population, at the national as well as the provincial level. As a result, most of the population is concentrated in the coastal regions and cities, and Mozambique has one of the highest levels of fertility, mortality, and illiteracy in the world.

In this agricultural country, high levels of fertility and mortality result in a young population pyramid, which will remain for some time. The age structure, high levels of fertility and mortality especially among the poor, and the variability in population distribution are a significant preoccupation of the government. Additionally, HIV/AIDS poses a real policy issue. The HIV prevalence rate in Mozambique is relatively low compared to neighboring countries because of two factors: the socialist politics during the period immediately following independence and the armed conflict which lasted until 1992. Also, the fact that commercial sex was illegal and that population movement was restricted contributed to the late initialization of the epidemic.

The policy shift in 1987 to a market economy, as well as the Peace Agreement in 1992 ending the civil war, both created conditions which were favorable not only for stability within the country, but also for sexual behavior which resulted in the rise of HIV prevalence. In order for the prevalence rate of HIV in Mozambique to remain lower than in neighboring countries, remedies are needed to limit the expansion of the epidemic.

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APPENDIX. DIVISÃO POLÍTICO-ADMINISTRATIVA NOS CENSOS REALIZADOS DE 1960 a 1997.

RECENSEAMENTO DA POPULAÇÃO DE 1960

A divisão político-administrativa usada no Censo de 1960 sofreu algumas alterações em relação a do recenseamento de 1955. Assim:

- No então Distrito de Lourenço Marques foi criado o Concelho da Matola e a Circunscrição da Namaacha
- Em de Gaza foi criado o Concelho do Baixo Limpopo
- No Distrito de Manica e Sofala foi criado o Concelho do Dondo
- No Distrito de Tete foram criadas as Circunscrições de Mágoè e Moatize.
- No Distrito de Moçambique (Nampula) foram criadas as Circunscrições de Monapo e Murrupula.

Portanto, a divisão político-administrativa em vigor na altura do recenseamento era seguinte:

Distrito de Lourenço Marques
Concelho:
Lourenço Marques
Manhiça
Matola
Circunscrições:
Maputo
Marracuene
Namaacha
Sábiè

Distrito de Gaza
Concelho:
Gaza
Baixo Limpopo
Bilene
Chibuto
Muchopes
Circunscrições:
Guijá
Limpopo
Magude

Distrito de Inhambane
Concelhos:
Inhambane
Circunscrições:
Govuro
Homoíne
Inharrime
Massinga
Morrumbene
Panda
Vilanculos
Zavala

Distrito de Manica e Sofala
Concelhos:
Beira
Chimoio
Dondo
Manica
Circunscrições:
Báruè
Búzi
Chemba
Cheringoma
Gorongosa
Marromeu
Mossurize
Sena
Sofala

Distrito de Tete
Concelho:
Tete
Circunscrições:
Angónia
Macanga
Máguè
Marávia
Moatize
Mutarara
Zumbo

Distrito da Zambézia
Concelhos:
Quelimane
Chinde
Mocuba
Circunscrições:
Alto Molócuè
Guruè
Ile
Lugela
Maganja da Costa
Milange
Mopeia
Morrumbala
Namacurra
Namarroi
Pebane

Distrito de Moçambique (Nampula)
Concelhos:
Nampula
Moçambique
António Enes
Circunscrições:
Eráti
Imala
Malema
Meconta
Memba
Mogincual
Mogovolas
Moma
Monapo
Mossuril
Murrupula
Nacala
Ribáuè

Distrito de Cabo Delgado
Concelhos:
Porto Amélia
Ibo
Mocímboa da Praia
Montepuez
Circunscrições:
Macomia
Macondes
Mecúfi
Palma
Quissanga

Distrito do Niassa
Concelho:
Vila Cabral
Circunscrições:
Amaramba
Maniamba
Marrupa

RECENSEAMENTO DA POPULAÇÃO DE 1970

A divisão político-administrativa usada no Censo de 1970 sofreu algumas alterações em relação a do recenseamento de 1960. Assim:

- A circunscrição de Magude no Distrito de Gaza integrou-se no Distrito de Lourenço Marques como Concelho.
- A circunscrição do Guijá (Distrito de Gaza) passou a denominar-se Caniçado.
- No Distrito de Inhambane foi criado o Concelho de Maxixe.
- Foi criado o Concelho de Caia no Distrito de Manica e Sofala.
- No Distrito de Tete foi criada a Circunscrição de Bene.
- No Distrito de Moçambique foi criada a Circunscrição de Nacala-a-Velha e foi extinta a Circunscrição de Imala.
- No Distrito do Niassa foram criadas as Circunscrições de: Lago, Mandimba, Maúa, Mecula, Sanga e Valadim e foi extinta a Circunscrição de Maniamba.

Divisão Administrativa em vigor na altura do recenseamento

Distrito de Lourenço Marques
Concelhos:
Lourenço Marques
Magude
Manhiça
Maputo
Marracuene
Matola
Namaacha
Sábiè

Distrito de Gaza
Concelhos:
Gaza
Baixo Limpopo
Bilene
Caniçado
Chibuto Muchopes
Limpopo
Muchopes

Distrito de Inhambane
Concelhos:
Inhambane
Homoíne
Massinga
Maxixe
Morrumbene
Vilanculos
Circunscrições:
Govuro
Inharrime
Panda
Zavala

Distrito de Manica e Sofala
Concelhos:
Beira
Báruè
Búzi
Caia
Cheringoma
Chimoio
Dondo
Manica
Marromeu
C*ircunscrições:*
Chemba
Gorongoza
Mossurize
Mungári
Sofala

Distrito de Tete

Concelhos:
Tete
Angónia
Macanga
Moatize
Mutarara

Circunscrições:
Bene
Mágoè
Marávia
Zumbo

Distrito da Zambézia

Concelhos:
Quelimane
Alto Molócuè
Chinde
Guruè
Maganja da Costa
Milange
Mocuba
Namacurra

Circunscrições:
Gilé
Ile
Lugela
Mopeia
Morrumbala
Namarroi
Pebane

Distrito de Moçambique (Nampula)

Concelhos:
Nampula
António Enes
Eráti
Fernão Veloso
Meconta
Moçambique
Moma
Monapo
Mossuril
Ribáuè

Circunscrições:
Malema
Mecuburi
Memba
Mogincual
Mogovolas
Muecate
Murrupula
Nacala-a-Velha

Distrito de Cabo Delgado

Concelhos:
Porto Amélia
Ibo
Macomia
Mocímboa da Praia
Montepuez

Circunscrições:
Macondes
Mecúfi
Namuno
Palma
Quissanga

Distrito do Niassa

Concelhos:
Vila Cabral
Amaramba

Circunscrições:
Lago
Mandimba
Marrupa
Maúa
Mecula
Sanga
Valadim

RECENSEAMENTO DA POPULAÇÃO DE 1980

Com o alcance da Independência Nacional em 1975 a divisão político-administrativa sofreu muitas alterações. A designação anterior de Concelho ou Circunscrição passou para Distrito, o Distrito para Província.

A grande alteração da divisão político-administrativa foi o desmembramento do antigo distrito de Manica e Sofala que passou separadamente a Província de Manica e Província de Sofala. O antigo Distrito de Lourenço Marques também desmembrou-se e grande parte da sua área passou a constituir a **Província de Maputo.**

As alterações havidas foram as seguintes:

Província do Niassa

- Amaramba passou a chamar-se Cuamba.
- Vila Cabral passou a designar-se Lichinga.
- Valadim passou a chamar-se Mavago.

Foram criados os seguintes distritos de: Majune e Mecanhelas.

Província de Cabo Delgado

- Macondes passou a chamar-se Mueda.
- Porto Amélia passou a chamar-se Ancuabe.

Foram criados os seguintes distritos de: Chiúre, Meluco, e Pemba Cidade e Pemba Metuge.

Província de Nampula

- António Enes passou a chamar-se Angoche.
- Fernão Veloso passou a chamar-se Nacala (cidade).

Foi criado o distrito de: Maiaia.

Província da Zambézia

Esta Província não sofreu quase nenhuma alteração a não ser a divisão de Quelimane Cidade e Quelimane distrito.

Província de Tete

- Bene passou a chamar-se Chiúta.
- Foram criados 2 novos Distritos: Changara e Cahora Bassa.

Província de Manica

Esta Província separou-se da de Manica e Sofala e passou a ser constituída pelos seguintes Distritos: Báruè, Tambara (novo), Chimoio Manica Mossurize, Guro (antes chamava-se Mungári) e Sussundenga (novo).

Província de Sofala

Esta província passou a ser integrado pelos seguintes Distritos: Beira, Buzi, Caia Chemba, Cheringoma, Chibabava (novo distrito), Dondo, Gorongosa e Marromeu.

Província de Inhambane

Esta Província a única alteração foi a integração de Maxixe na Cidade de Inhambane.

Província de Gaza

- Baixo Província de Maputo Limpopo passou a chamar-se Chókwè.

- Limpopo passou a chamar-se Chicualacuala.
- Muchopes passou a chamar-se Manjacaze.

Foi criado o distrito de: Massingir.

Antigo distrito de Lourenço Marques desmembrou-se e passou constituir a Província de Maputo sem a Matola. Sábeè passou a chamar-se Moamba e Maputo passou a chamar-se Matutuíne.

Maputo Cidade

A cidade capital com o estatuto de Provincia integrando a Matola.

Divisão Administrativa em vigor na altura do recenseamento.

Província do Niassa
Distritos:
Cuamba
Lago
Lichinga (Cidade)
Majune
Mandimba
Marrupa
Maúa
Mecanhelas
Mecula
Sanga
Mavago
Lichinga (Distrito)

Província de Cabo Delgado
Distritos:
Chiúre
Ibo
Macomia
Mueda
Mecúfi
Meluco
Mocímboa da Praia
Montepuez
Namuno
Palma
Pemba (Cidade)
Pemba (Distrito)
Ancuabe
Quissanga

Província de Nampula
Distritos:
Nampula (Distrito)
Angoche
Eráti
Mecuburi
Maiaia
Malema
Meconta
Memba
Moçambique
Mogincual
Mogovolas
Moma
Monapo
Mossuril
Muecate
Murrupula
Nacala (Cidade)
Nacala
Nampula (Cidade)
Ribáuè

Província da Zambézia
Distritos:
Alto Molócuè
Chinde
Gilé
Guruè
Ile
Lugela
Maganja da Costa
Milange
Mocuba
Mopeia
Morrumbala
Namacurra
Namarroi
Pebane
Quelimane (Cidade)
Quelimane (Distrito)

Província de Tete
Distritos:
Changara
Angónia
Chiuta
Cahora Bassa
Macanga
Mágoè
Marávia
Moatize
Mutarara
Tete (Cidade)
Zumbo

Província de Manica
Distritos:
Báruè
Tambara
Chimoio (Cidade)
Chimoio (Distrito)
Manica
Mossurize
Guro
Sussundenga

Província de Sofala
Distritos:
Beira (Cidade)
Búzi
Caia
Chemba
Chringoma
Chibabava
Dondo
Gorongosa
Marromeu

Província de Inhambane
Distritos:
Govuro
Homoíne
Inhambane
Inharrime
Massinga
Inhambane (Cidade)
Morrumbene
Panda
Vilanculos
Zavala

Província de Gaza
Distritos:
Chókwè
Bilene
Chibuto
Chókwè (Cidade)
Xai-Xai
Caniçado
Chicualacuala
Massingir
Manjacaze
Xai-Xai (Cidade)

Província de Maputo
Distritos:
Magude
Manhiça
Matutuíne
Marracuene
Boane
Namaacha
Moamba

Maputo Cidade

Integrava a Cidade da Matola

RECENSEAMENTO DA POPULAÇÃO DE 1997

A Lei N.º 6/86 de 25 de Julho estabeleceu a alteração da divisão territorial do País, com a criação de novos Distritos nalgumas Províncias.

As alterações havidas foram as seguintes:

Província do Niassa

- Foram criados os seguintes Distritos: Metarica, Muembe, N'gauma e Nipepe.

Província de Cabo Delgado

- Foram criados os Distritos de: Muidumbe, Nangade e Balama.

Província de Nampula

- O Distrito de Maiaia passou a chamar-se Lalaua e foi criado o Distrito de Nacarôa.

Província da Zambézia

- O Distrito de Quelimane passou a chamar-se Inhassunge e foi criado o Distrito de Nicoadala.

Província de Tete

- Foram criados os seguintes Distrito s de: Chifunde e Tsangano.

Província de Manica

- O de Chimoio passou a designar-se Gondola e foram criados os Distritos de Macossa e Machaze.

Província de Sofala

- Foram criados os Distritos de: Nhamatanda, Machanga, Muanza e Marínguè.

Província de Inhambane

- Maxixe separou-se da Cidade de Inhambane passando a ter o estatuto de Cidade.
- O Distrito de Inhambane passou a chamar-se Jangamo e foram criados outros 3: Mabote, Inhassoro e Funhalouro.

Província de Gaza

- O Distrito de Caniçado passou a chamar-se Guijá.
- Foram criados os Distritos de: Massangena, Chigubo e Mabalane.

Província de Maputo

- A Matola separou-se da Cidade de Maputo para passar a ter estatuto de Cidade.

Maputo Cidade

- Três Distritos urbanos (6, 7, e 8) passaram a fazer parte da Cidade da Matola.

Divisão Administrativa em vigor na altura do recenseamento.

Província do Niassa
Distritos:
Cuamba
Lago
Lichinga (Cidade)
Majune
Mandimba
Marrupa
Maúa
Mecanhelas
Mecula
Metarica
Muembe
N'gauma
Nipepe
Sanga
Mavago
Lichinga (Distrito)

Província de Cabo Delgado
Distritos:
Chiúre
Ibo
Macomia
Mueda
Mecúfi
Meluco
Mocímboa da Praia
Montepuez
Muidumbe
Namuno
Nangade
Palma
Pemba (Cidade)
Pemba Metuge
Ancuabe
Quissanga
Balama

Província de Nampula
Distritos:
Nampula (Distrito)
Angoche
Eráti
Mecuburi
Maiaia
Malema
Meconta
Memba
Moçambique
Mogincual
Mogovolas
Moma
Monapo
Mossuril
Muecate
Murrupula
Nacala (Cidade)
Nacala-a-Velha
Nampula (Cidade)
Ribáuè
Nacarôa

Província da Zambézia
Distritos:
Alto Molócuè
Chinde
Gilé
Guruè
Ile
Lugela
Maganja da Costa
Milange
Mocuba
Mopeia
Morrumbala
Namacurra
Namarroi
Pebane
Quelimane (Cidade)
Inhassunge
Nicoadala

Província de Tete
Distritos:
Changara
Angónia
Chiuta
Cahora Bassa
Macanga
Mágoè
Marávia
Moatize
Mutarara
Tete (Cidade)
Zumbo
Chifunde
Tsangano

Província de Manica
Distritos:
Báruè
Tambara
Chimoio (Cidade)
Gondola
Manica
Mossurize
Guro
Sussundenga
Macossa
Machaze

Província de Sofala
Distritos:
Beira (Cidade)
Búzi
Caia
Chemba
Chringoma
Chibabava
Dondo
Gorongosa
Marromeu
Nhamatanda
Machanga
Muanza
Marínguè

Província de Inhambane
Distritos:
Govuro
Homoíne
Jangamo
Inharrime
Massinga
Inhambane (Cidade)
Morrumbene
Panda
Vilanculos
Zavala
Maxixe (Cidade)
Mabote
Inhassoro
Funhalouro

Província de Gaza
Distritos:
Chókwè
Bilene
Chibuto
Chókwè (Cidade)
Xai-Xai
Guijá
Chicualacuala
Massingir
Manjacaze
Xai-Xai (Cidade)
Massangena
Chigubo
Mabalane

Província de Maputo
Distritos:
Magude
Manhiça
Matutuíne
Marracuene
Boane
Namaacha
Moamba
Matola (Cidade)

Maputo Cidade

Appendix Table A. Population, distribution and density according to the population censuses of 1960 and 1970.

Census of 1960		Census of 1970			
Concelhos and Circunscricoes	**Population**	**Concelhos and Circunscricoes**	**Population**	**Area (km)**	Density (p/km)
PAÍS	**6,603,653**	**PAÍS**	**8,168,933**	**801,590**	
NIASSA	**281,083**	**NIASSA**	**285,329**	**129,056**	**2.2**
Circ. de Amaramba	92,455	Conc. de Amaramba	99,645	14,720	6.8
Conc. de Vila Cabral	83,744	Conc. de Vila Cabral	57,746	13,627	4.2
Circ. de Maniamba	48,415	Circ. de Mandimba	27,239	13,639	2.0
Circ. de Marrupa	56,469	Circ. de Marrupa	25,011	17,730	1.4
		Circ. do Lago	13,457	13,053	1.0
		Circ. de Maúa	43,201	15,292	2.8
		Circ. de Mecula	4,855	14,554	0.3
		Circ. de Sanga	10,021	12,185	0.8
		Circ. de Valentim	4,154	14,256	0.3
CABO DELGADO	**548,597**	**CABO DELGADO**	**546,113**	**82,625**	**6.6**
Conc. de Porto Amélia	55,166	Conc. de Porto Amélia	76,947	5,836	13.2
Conc. do Ibo	4,230	Conc. do Ibo	6,534	48	136.1
Conc. da Mocímboa da Praia	46,880	Conc. da Mocímboa da Praia	22,725	4,708	4.8
Conc. de Montepuez	156,698	Conc. de Montepuez	107,566	12,118	8.9
Conc. de Macomia	38,566	Conc. de Macomia	33,983	4,049	8.4
Circ. dos Macondes	79,024	Circ. dos Macondes	13,514	24,935	0.5
Circ. de Mecufi	94,901	Circ. de Mecufi	125,797	4,427	28.4
Circ. de Palma	41,605	Circ. de Palma	19,244	6,524	2.9
Circ. de Quissanga	31,527	Circ. de Quissanga	36,741	7,900	4.7
		Circ. de Namuno	103,062	12,080	8.5

Census of 1960		Census of 1970			
Concelhos and Circunscricoes	**Population**	**Concelhos and Circunscricoes**	**Population**	**Area (km)**	Density (p/km)
NAMPULA	**1,452,395**	**NAMPULA**	**1,716,486**	**83,816**	**20.5**
Conc. de Nampula	103,985	Conc. de Nampula	124,156	3,970	31.3
Conc. de António Enes	119,652	Conc. de António Enes	150,277	3,361	44.7
Circ. de Eráti	162,925	Circ. de Eráti	213,011	8,564	24.9
Circ. de Nacala	87,523	Conc. de Fernão Veloso	62,953	1,586	39.7
Circ. de Meconta	56,740	Conc. de Meconta	66,956	3,733	17.9
Conc. de Moçambique	12,002	Conc. de Moçambique	21,906	446	49.1
Circ. de Moma	121,933	Conc. de Moma	137,162	5,677	24.2
Circ. de Monapo	115,461	Conc. de Monapo	130,603	3,598	36.3
Circ. de Mossuril	73,023	Conc. de Mossuril	57,796	2,847	20.3
Circ. de Ribáuè	76,056	Conc. de Ribáuè	89,050	10,659	8.4
Circ. de Malema	40,815	Circ. de Malema	59,418	6,122	9.7
Circ. de Imala	91,372	Circ. de Mecuburi	66,470	7,252	9.2
Circ. de Memba	104,317	Circ. de Memba	119,802	4,891	24.5
Circ. de Mongincual	77,536	Circ. de Mongincual	81,914	4,274	19.2
Circ. de Mogovolas	148,595	Circ. de Mogovolas	173,211	4,771	36.3
Circ. de Morrupula	60,460	Circ. de Morrupula	70,607	3,417	20.7
		Circ. de Muecate	39,474	4,374	9.0
		Circ. de Nacala-a-Velha	51,720	4,274	12.1
ZAMBÉZIA	**1,368,731**	**ZAMBÉZIA**	**1,747,888**	**105,008**	**16.6**
Circ. do Alto Molócuè	127,634	Conc. do Alto Molócuè	106,249	6,386	16.6
Conc. do Chinde	95,401	Conc. do Chinde	97,968	4,291	22.8
Circ. do Guruè	81,623	Conc. do Guruè	105,702	5,606	18.9
Circ. do Ile	150,252	Circ. do Ile	184,264	5,589	33.0
Circ. de Lugela	68,736	Circ. de Lugela	76,137	8,178	9.3
Circ. da Maganja da Costa	126,719	Circ. da Maganja da Costa	161,162	7,597	21.2
Circ. de Milange	118,969	Conc. de Milange	170,905	9,794	17.4
Conc. de Mocuba	76,101	Conc. de Mocuba	107,779	9,062	11.9
Circ. de Mopeia	46,159	Circ. de Mopeia	56,242	7,476	7.5
Circ. de Morrumbala	102,864	Circ. de Morrumbala	140,586	12,811	11.0
Circ. de Namacurra	96,069	Circ. de Namacurra	120,177	4,038	29.8
Circ. de Namaroi	55,788	Circ. de Namaroi	76,350	3,019	25.3
Circ. de Pebane	70,095	Circ. de Pebane	91,300	9,985	9.1
Conc. de Quelimane	152,321	Conc. de Quelimane	183,609	2,301	79.8
		Conc. do Gilé	69,458	8,875	7.8

Appendix Table A (continued).

Census of 1960		Census of 1970			
Concelhos and Circunscricoes	**Population**	**Concelhos and Circunscricoes**	**Population**	**Area (km)**	Density (p/km)
TETE	**471,352**	**TETE**	**488,668**	**100,724**	**4.9**
Conc. de Tete	67,553	Conc. de Tete	93,076	12,705	7.3
Circ. de Angónia	110,599	Conc. de Angónia	103,704	4,611	22.5
Circ. de Macanga	60,513	Conc. de Macanga	32,938	18,141	1.8
Circ. de Mágoè	22,555	Circ. de Mágoè	31,263	12,043	2.6
Circ. da Marávia	33,773	Circ. da Marávia	10,225	16,396	0.6
Circ. de Moatize	46,762	Conc. de Moatize	59,229	10,940	5.4
Circ. do Zumbo	19,159	Circ. do Zumbo	19,092	14,011	1.4
Circ. de Mutarara	110,438	Conc. de Mutarra	136,074	6,295	21.6
		Circ. de Bene	3,067	5,582	0.5
MANICA E SOFALA	**779,767**		**1,079,718**	**129,679**	**8.3**
Conc.da Beira	58,970	Conc. da Beira	130,398	595	219.2
Conc. do Chimoio	62,510	Conc. do Chimoio	113,510	8,009	14.2
Conc. do Dondo	29,917	Conc. do Dondo	54,977	7,020	7.8
Conc. de Manica	57,940	Conc. de Manica	93,168	9,377	9.9
Circ. do Báruè	81,677	Conc. do Báruè	52,267	15,312	3.4
Circ. do Búzi	108,283	Conc. do Búzi	116,030	11,014	10.5
Circ. de Chemba	79,373	Circ. de Chemba	95,835	10,460	9.2
Circ. de Cheringoma	31,088	Conc. de Cheringoma	44,300	14,470	3.1
Circ. de Gorongosa	44,573	Circ. de Gorongosa	60,522	7,579	8.0
Circ. de Marromeu	41,794	Conc. de Marromeu	44,798	5,810	7.7
Circ. de Mossurize	97,876	Circ. de Mossurize	108,392	18,388	5.9
Circ. de Sena	46,141	Conc. de Caia	54,320	3,477	15.6
Circ. de Sofala	39,625	Circ. de Nova Sofala	51,283	9,064	5.7
		Circ. de Mungári	59,918	9,104	6.6
INHAMBANE	**583,059**		**748,575**	**68,615**	**10.9**
Conc. de Inhambane	67,381	Conc. de Inhambane	83,980	1,480	56.7
Circ. de Govuro	38,145	Circ.de Govuro	60,292	19,077	3.2
Circ. de Homoíne	87,227	Conc. de Homoíne	69,865	1,942	36.0
Circ. de Inharrime	40,686	Circ.de Inharrime	57,278	2,565	22.3
Circ. de Massinga	109,066	Conc. de Massinga	148,403	20,415	7.3
Circ. de Morrumbene	68,443	Conc. de Morrumbene	75,579	2,800	27.0
Circ. de Panda	35,496	Circ.de Panda	35,097	7,204	4.9
Circ. de Vilanculos	67,359	Conc. de Vilanculos	96,616	10,882	8.9
Circ. de Zavala	69,256	Circ.de Zavala	81,443	1,968	41.4
		Conc. de Maxixe	40,022	282	141.9

Census of 1960		Census of 1970			
Concelhos and Circunscricoes	**Population**	**Concelhos and Circunscricoes**	**Population**	**Area (km)**	Density (p/km)
GAZA	**681,753**		**756,654**	**75,709**	**10.0**
Conc. de Gaza	100,379	Conc. de Gaza	124,265	1,876	66.2
Conc. do Baixo Limpopo	74,640	Conc. do Baixo Limpopo	90,670	45,937	29.7
Conc. do Bilene	83,359	Conc. do Bilene	80,133	3,052	26.3
Conc. do Chibuto	141,936	Conc. do Chibuto	204,904	6,331	32.4
Conc. dos Muchopes	126,833	Conc. dos Muchopes	139,276	3,665	38.0
Circ. do Guijá	55,233	Conc. do Caniçado	70,672	11,615	6.1
Circ. do Limpopo	36,760	Conc. do Limpopo	46,734	3,233	14.5
Circ. de Magude	62,613				
LOURENÇO MARQUES	**436,916**		**799,502**	**26,358**	**30.3**
Conc. de Lourenço Marques	178,565	Conc. de Lourenço Marques	378,348	67	5647.0
Conc. da Manhiça	75,669	Conc. da Manhiça	97,539	3,375	28.9
Conc. da Matola	48,446	Conc. da Matola	86,979	1,321	65.8
Circ. do Maputo	41,699	Circ. do Maputo	46,112	6,876	6.7
Circ. de Marracuene	34,642	Circ. de Marracuene	39,166	1,087	36.0
Circ. da Namaacha	11,075	Circ. da Namaacha	16,534	2,144	7.7
Circ. do Sábiè	46,820	Circ. do Sábiè	59,277	4,528	13.1
		Conc. de Magude	75,547	6,960	10.9

Appendix Table B. Population, distribution and density according to the population censuses of 1980 and 1997.

Census of 1980

Provinces and DIstricts	Population	Area (km)	Density (p/km)
PAÍS	**3,650,265**	**293,287**	**12.4**
NIASSA	**507,816**	**129,056**	3.9
Amaramba	84,068	8,610	9.8
Lago	37,401	6,528	5.7
Mandimba	63,304	8,345	7.6
Marrupa	30,811	17,730	1.7
Maua	58,641	13,249	4.4
Mecula	7,090	18,153	0.4
Sanga	23,167	12,185	1.9
Lichinga	51,657	4,479	11.5
Mavago	21,701	15,085	1.4
Majune	20,284	11,155	1.8
Mecanhelas	70,688	6,406	11.0
Lichinga Cidade	39,004	251	155.4
Águas Interiores		**6,880**	
CABO DELGADO	**900,704**	**82,625**	**10.9**
Ancube	43,991	3,509	12.5
Ibo	5,870	48	122.3
Mocímboa da Praia	48,059	4,708	10.2
Montepuez	140,502	9,763	14.4
Namuno	154,565	10,045	15.4
Macomia	54,598	4,049	13.5
Mueda	132,503	24,935	5.3
Mecufi	34,592	1,283	27.0
Chiure	109,030	3,072	35.5
Palma	63,115	6,524	9.7
Quissanga	26,683	2,061	12.9
Meluco	20,181	5,799	3.5
Pemba Cidade	41,166	181	227.4
Pemba	25,849	1,890	13.7
Águas Interiores		**4,758**	
NAMPULA	**2,241,745**	**81,606**	**27.5**
Nampula	83,110	3,673	22.6
Angoche	178,302	2,986	59.7
Eráti	273,924	8,464	32.4
Nacala	74,573	967	77.1
Meconta	81,399	3,733	21.8
Ilha de Moçambique	30,152	226	133.4
Moma	167,222	5,677	29.5
Monapo	182,202	3,598	50.6
Mossuril	67,407	2,658	25.4
Ribáuè	128,808	10,659	12.1
Malema	86,169	6,122	14.1
Mecuburi	81,208	7,252	11.2
Muecate	52,327	4,075	12.8
Memba	148,818	4,555	32.7
Mogincual	89,043	4,274	20.8
Mogovolas	192,153	4,771	40.3
Morrupula	84,898	3,100	27.4
Maiaia	19,270	774	24.9
Nampula Cidade	145,722	297	490.6
Nacala Cidade	75,038	336	223.3
Águas Interiores		**3,409**	

Census of 1997

Provinces and Districts	Population	Area (km)	Density (p/km)
PAÍS	**5,019,848**	**293,287**	**17.1**
NIASSA	**756,287**	**129,056**	**5.9**
Cuamba	126,380	5,121	24.7
Lago	55,892	6,528	8.6
Mandimba	84,011	4,385	10.4
Marrupa	40,199	17,730	2.3
Maua	38,390	9,957	3.9
Mecula	10,972	18,153	0.6
Sanga	44,225	12,185	3.6
Lichinga	62,802	8,075	7.8
Mavago	12,381	9,559	2.2
Majune	20,571	9,059	8.4
Mecanhelas	76,311	6,406	11.9
Lichinga Cidade	85,758	290	295.7
Metarica	20,430	3,489	5.9
Muembe	18,680	5,526	3.4
N´gauma	33,721	2,421	13.9
Nipepe	25,564	3,292	7.8
Águas Interiores		**6,880**	
CABO DELGADO	**1,287,814**	**82,625**	**15.6**
Ancuabe	87,243	4,606	18.9
Ibo	7,061	48	147.1
Mocimboa da Praia	75,001	3,548	21.1
Montepuez	149,181	15,871	9.4
Namuno	138,229	6,915	20.0
Macomia	69,973	4,049	17.3
Mueda	98,654	14,150	7.0
Mecufi	35,644	1,192	29.9
Chiúre	185,618	4,210	44.1
Palma	42,182	3,493	12.1
Quissanga	34,328	2,061	16.7
Meluco	23,912	5,799	4.1
Pemba Cidade	84,897	194	437.6
Pemba Metuge	42,935	1,094	39.2
Balama	98,653	5,619	17.6
Muidumbe	63,820	1,987	32.1
Nangade	50,483	3,031	16.7
Águas Interiores		**4,758**	
NAMPULA	**2,975,747**	**81,606**	**36.5**
Nampula Rapale	127,681	3,650	35.0
Angoche	228,526	2,986	76.5
Eráti	210,239	5,671	37.1
Nacala-Velha	77,918	967	80.6
Meconta	123,097	3,733	33.0
Ilha de Moçambique	42,407	226	187.6
Moma	238,655	5,677	42.0
Monapo	226,968	3,598	63.1
Mossuril	89,457	3,428	26.1
Ribáuè	128,209	6,281	20.4
Malema	128,732	6,122	21.0
Mecuburi	118,726	7,252	16.4
Muecate	69,619	4,075	17.1
Memba	188,992	4,555	41.5
Mogincual	92,320	4,274	21.6
Mogovolas	182,184	4,771	38.2
Murrupula	101,745	3,100	32.8
Lalaua	55,912	4,378	12.8
Nampula Cidade	303,346	320	948.0
Nacala Porto	158,248	340	465.4
Nacaroa	82,766	2,793	29.6
Águas Interiores		**3,409**	

ZAMBÉZIA	**2,418,851**	**105,008**	23.0	**ZAMBÉZIA**	**########**	**105,008**	**27.5**
Alto Molocue	143,390	6,386	22.5	Alto Molocue	185,224	6,386.0	29.0
Chinde	136,597	4,403	31.0	Chinde	129,115	4,403.0	29.3
Gilé	93,411	8,875	10.5	Gilé	126,988	8,875.0	14.3
Gurue	166,265	5,606	29.7	Gurue	197,179	5,606.0	35.2
Ile	253,787	5,589	45.4	Ile	224,167	5,589.0	40.1
Lugela	103,018	6,178	16.7	Lugela	106,770	6,178.0	17.3
Maganja da Costa	205,561	7,597	27.1	Maganja da Costa	229,230	7,597.0	30.2
Milange	291,445	9,794	29.8	Milange	335,728	9,794.0	34.3
Mocuba	146,511	8,867	16.5	Mocuba	214,748	8,867.0	24.2
Mopeia	64,351	7,614	8.5	Mopeia	71,535	7,614.0	9.4
Morrumbala	197,554	12,972	15.2	Morrumbala	243,751	12,972.0	18.8
Namacurra	163,128	3,941	41.4	Namacurra	160,879	1,798.0	89.5
Namarroi	94,939	3,019	31.4	Namarroi	95,257	3,019.0	31.6
Pebane	117,022	9,985	11.7	Pebane	198,451	9,985.0	19.9
Quelimane	181,721	2,159	84.2	Quelimane Cidade	150,116	117.0	1283.0
Quelimane Cidade	60,151	142	423.6	Nocoadala	135,275	3,582.0	37.8
				Inhassunge	87,396	745.0	117.3
Águas Interiores		**1,881**		**Águas Interiores**	**1,881**		
TETE	**780,081**	**100,724**	7.7	**TETE**	**1,144,604**	**100,724**	**11.4**
Changara	86,493	12,340	7.0	Changara	119,551	6,730	17.8
Angónia	220,085	6,876	32.0	Angónia	247,999	3,437	72.2
Macanga	37,162	14,531	2.6	Macanga	46,515	7,430	6.3
Chiuta	39,532	9,326	4.2	Chiuta	50,372	7,101	
Mágoè	9,915	6,726	1.5	Mágoè	39,304	8,697	4.5
Cabora-Bassa	47,679	7,938	6.0	Cabora-Bassa	57,675	10,598	
Marávia	33,214	13,661	2.4	Marávia	53,031	16,466	3.2
Moatize	98,101	8,734	11.2	Moatize	109,103	8,879	12.3
Zumbo	31,566	14,011	2.3	Zumbo	33,272	12,040	2.8
Mutarara	131,215	6,295	20.8	Mutarara	130,743	6,295	20.8
Tete Cidade	45,119	286	157.8	Tete Cidade	101,984	286	356.6
				Chifunde	48,498	9,326	5.2
				Tsangano	106,557	3,439	31.0
MANICA	**587,345**	**61,661**	**9.5**	**MANICA**	**974,208**	**61,661**	**15.8**
Barue	69,786	15,184	4.6	Barue	81,002	5,750	14.1
Chimoio	145,902	7,767	18.8	Gondola	184,629	5,290	34.9
Guro	50,886	6,609	7.7	Guro	45,680	6,920	6.6
Manica	53,167	2,234	23.8	Manica	155,731	4,391	35.5
Mossurize	124,421	18,234	6.8	Mossurize	122,244	5,096	24.0
Sussundenga	48,873	6,952	7.0	Sussundenga	92,622	7,060	13.1
Tambara	26,185	4,506	5.8	Tambara	31,471	4,316	7.3
Chimoio Cidade	68,125	175	389.3	Chimoio Cidade	171,056	174	983.1
				Machaze	75,804	13,112	5.8
				Macossa	13,969	9,552	1.5
SOFALA	**990,732**	**68,018**	**14.6**	**SOFALA**	**########**	**68,018**	**19.0**
Buzi	144,265	8,379	17.2	Buzi	143,152	7,409	19.3
Caia	81,169	3,477	23.3	Caia	86,001	3,477	24.7
Chemba	70,078	5,786	12.1	Chemba	49,634	4,388	11.3
Cheringoma	65,072	14,470	4.5	Cheringoma	20,795	8,739	2.4
Chibabava	112,980	11,699	9.7	Chibabava	72,273	8,012	9.0
Dondo	120,562	6,456	18.7	Dondo	117,719	2,443	48.2
Gorongosa	106,079	11,346	9.3	Gorongosa	77,877	7,659	10.2
Marromeu	75,914	5,810	13.1	Marromeu	69,895	5,810	12.0
Beira	214,613	595	360.7	Beira	397,368	633	627.8
				Machanga	44,784	4,657	9.6
				Maringue	56,654	5,085	11.1
				Muanza	15,308	5,731	2.7
				Nhamatanda	137,930	3,975	34.7
INHAMBANE	**1023879.0**	**68615.0**	**14.9**	**INHAMBANE**	**########**	**68,615**	**16.4**
Govuro	84,445	19,077	4.4	Govuro	29,031	4,584	6.3
Inharrime	64,725	2,149	30.1	Inharrime	76,518	2,149	35.6
Massinga	220,329	20,415	10.8	Massinga	186,650	5,324	35.1
Morrumbene	106,621	2,800	38.1	Morrumbene	110,817	2,358	47.0
Panda	56,131	6,971	8.1	Panda	46,539	6,971	6.7
Vilanculos	152,892	10,882	14.0	Vilanculos	113,045	4,700	24.1
Zavala	96,296	2,617	36.8	Zavala	126,730	2,617	48.4
Homoine	95,237	1,942	49.0	Homoine	92,796	1,942	47.8

Inhambane	56,439	1,396	40.4	Jangamo	81,210	1,288	63.1
Inhambane Cidade	90,764	366	154.2	Inhambane Cidade	52,370	192	272.8
				Funhalouro	30,321	15,678	1.9
				Inhassoro	43,406	6,299	6.9
				Mabote	39,661	14,231	2.8
				Cidade de Maxixe	93,985	282.0	333.3
GAZA	**982,603**	**75,709**	**13.0**	**GAZA**	**########**	**75,709**	**14.0**
Bilene Macia	109,643	1,917	57.2	Bilene Macia	133,173	2,719	49.0
Caniçado	69,346	7,331	9.5	Guijá	57,217	3,589	15.9
Massingir	29,810	5,858	5.1	Massingir	22,284	5,858	3.8
Chibuto	230,815	6,166	37.4	Chibuto	164,791	5,878	28.0
Chicualacuala	80,947	45,937	1.8	Chicualacuala	33,284	16,035	2.1
Gaza	120,488	1,734	69.5	Xai-Xai	165,596	1,739	95.2
Manjacaze	180,632	3,748	48.2	Manjacaze	161,147	3,748	43.0
Limpopo	106,257	2,638	40.3	Chokwé	116,986	1,864	62.8
Xai-Xai Cidade	43,794	142	308.4	Xai-Xai Cidade	99,442	135	736.6
Chokwé Cidade	10,871	68	159.9	Chokwé Cidade	56,291	91	619
				Chigubo	13,405	13,952	1.0
				Massagena	13,300	10,351	1.3
				Mabalane	25,464	9,580	2.7
Águas Interiores		**170**		**Águas Interiores**		**170**	
MAPUTO	**500,892**	**25,756**	**19.4**	**MAPUTO**	**806,179**	**26,058**	**30.9**
Manhiça	139,400	2,380	58.6	Manhiça	130,351	2,380	54.8
Matutuine	57,509	5,442	10.6	Matutuine	35,161	5,403	6.5
Marracuene	45,147	700	64.5	Marracuene	41,677	666	62.6
Boane	39,296	820	47.9	Boane	56,703	820	69.2
Namaacha	24,673	2,144	11.5	Namaacha	31,441	2,144	14.7
Moamba	90,856	4,528	20.1	Moamba	43,396	4,528	9.6
Magude	104,011	6,960	14.9	Magude	42,788	6,960	6.1
				Cidade da Matola	424,662	375	1132.4
Águas Interiores		**2,782**		**Águas Interiores**		**2,782**	
MAPUTO CIDADE	**739,077**	**602**	**1227.7**	**MAPUTO CIDADE**	**966,837**	**300**	**3222.8**
				Distrito Nº 1	154,284		
				Distrito Nº 2	162,750		
				Distrito Nº 3	210,551		
				Distrito Nº 4	228,244		
				Distrito Nº 5	211,008		

FUTURE SCENARIOS FOR POPULATION GROWTH IN MOZAMBIQUE, 1997-2020

Manuel da Costa Gaspar

Introduction

The rapid expansion of HIV infection and AIDS in Mozambique has become a tragedy of alarming proportions, which constitutes one of the major challenges to the country's development. It is causing a reduction in life expectancy due to an increase in mortality, and tens of thousands of orphans. Recent estimates indicate that in 2000, 16% of the adult population aged 15-49 was HIV positive, and that already more than 341,000 children were AIDS-orphans. More than 450,000 persons were infected and in 2000 alone, an estimated 84,000 people died of AIDS.

Mozambique is located among countries with the highest HIV prevalence rates in the world, for example, Botswana (36%), Lesotho, Namibia, South Africa (20%), Swaziland and Zimbabwe (25%). It is possible that the epidemic will spread quickly in Mozambique, in particular along the open corridors to neighboring countries, which facilitate the circulation of people and goods, as well as from labor migration to South Africa. The epidemic could compromise the recent Mozambican advances in human development.

Although Mozambique experienced high economic growth rates in recent years, the country has not recovered fully from the effects of the civil war: more than 60% of the population continues to live below the poverty line. An expansion of HIV prevalence places the country in a dramatic situation without the means to combat the disease. This precarious situation has led to the search for better estimates of future population growth, as well as improved data on the distribution and prevalence of HIV by increasing the number of sentinel posts.

In the past decade, the HIV/AIDS epidemic emerged silently and unexpectedly, due to a failure to interpret and communicate ongoing information about the situation, and expectations for the future. In the new century, as more data on HIV/AIDS become available, we can turn to interdisciplinary studies such as this one, which analyze the economic, social, and demographic effects of the epidemic.

This paper presents alternative scenarios of population growth in Mozambique. In spite of the limited data available in Mozambique on HIV/AIDS, it is hoped that the scenarios of this study, with a range of alternative assumptions concerning the increase of prevalence and interventions, will form a base for planning to combat the disease. In fact, the basic data on HIV/AIDS is not representative of the whole country. It was collected in four urban sentinels sites. Therefore, the results of the scenarios should be read with caution. This exercise is of an exploratory character and should not be seen as an alternative to the official national population projections.

Model Methodology

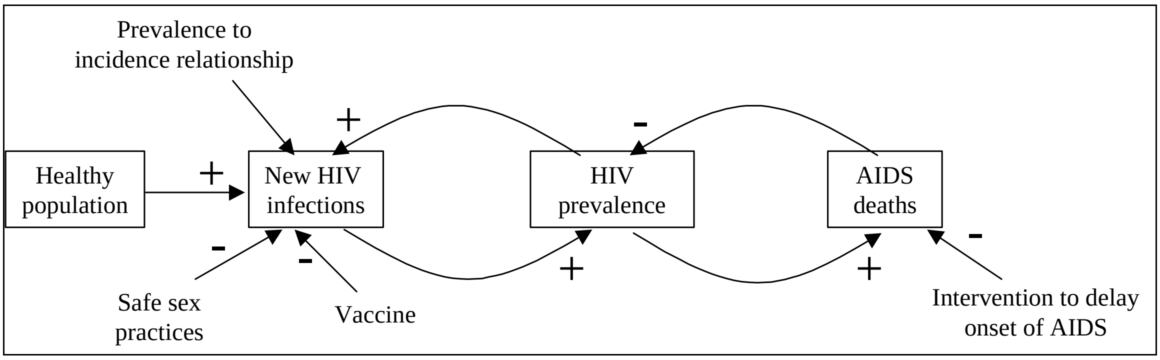
HIV is an infectious disease, which means there is a relationship between prevalence, incidence, and susceptible population. The most basic dynamic is that the more people are infected, the more the disease spreads to the healthy people, so in turn, the more are infected. How quickly new people are infected depends on the relationship between prevalence and incidence, which is determined by biology and behavior.

If an infected person is healed or dies right away, the prevalence never has a chance to build up and cause an epidemic. On the other hand, if an infected person lives with the infection for a long time, prevalence has the opportunity to increase. This is the case with HIV, where the average time until the outbreak of full-blown AIDS is estimated to be 7-10 years in Africa. Once a person in Africa has AIDS, the annual mortality is very high, at least 50% annually.

Factors that can limit the spread of the HIV infection are safe sex practices (especially behavioral change), treatment of other sexually transmitted diseases, bottle-feeding infants of HIV-positive mothers and other interventions. In the future a cheap vaccine might halt the disease.

Figure 1 shows these basic dynamics and the intervention points to limit HIV and AIDS. We have incorporated the relationship between prevalence and new incidence. If the relationship is higher, then HIV prevalence rises faster. The model also includes the three intervention possibilities in the figure. Further, all the dynamics are incorporated into a multi-state age and sex-specific population projection model.[3] With the model, we can make scenarios that take into account how different rates of the diffusion of HIV and the effects of various policies impact population growth and age structure.

Figure 1. Flow diagram of HIV and AIDS dynamics.



Scenarios

All of the scenarios have the same assumptions on fertility, migration, and non-AIDS mortality as those used in the official population projections of Mozambique (Instituto Nacional de Estatística. 1999). The base assumptions about HIV prevalence reproduce the projections by the Ministry of Health. These projections consider a rise in prevalence from the present 16% to a plateau of 17% by 2006 (Ministério da Saúde et al. 2000). Seven alternative scenarios were also considered, which can be divided into three groups: scenarios (1 and 3)

[3] The original version of this model was developed for Botswana by Warren Sanderson at the International Institute for Applied Systems Analysis, Laxenburg, Austria.

which vary the estimated spread of HIV in the absence of policy interventions; a scenario (2) with no AIDS; and scenarios (4-7) that measure the effects of policies that change sexual behavior, longevity of those with HIV, and a vaccine, using the Ministry of Health scenario as a base. The scenarios described here are:

1) **Base scenario low behavioral change:** Reproduces the HIV prevalence similar to that of the Ministry of Health (maximum rate 20%), using the fertility, mortality, and migration assumptions of Mozambique's official population projections. This is an optimistic scenario with regard to the spread of the disease. Condom use rises only slowly. In the Demographic and Health Survey 1997, it was found that only 3% of the women and 9% of the men used condoms to protect themselves against HIV/AIDS. This scenario assumes that a behavioral change, which could include increased condom use, will cause incidence rates to be 10% lower than they would be in the absence of any change by 2020.
2) **No AIDS:** Reproduces the official population projections.
3) **High HIV prevalence (or pessimistic scenario):** Assumes that HIV prevalence will continue to rise – based on the observation that the disease is presently in a stage of rapid expansion – and that HIV prevalence will reach 30% by 2020. It eventually stabilizes at 40% in 2025.
4) **Medium behavioral change:** Uses the same curve for HIV prevalence-to-incidence as Scenario 1, but assumes higher rates of behavioral change (mostly higher rates of condom use) that reduce the incidence rate by 25% compared to what it would be with no behavioral change.
5) **High behavioral change (or optimistic scenario):** As in 4 above, but with behavioral change causing an 80% reduction in incidence by 2020.
6) **High vaccination: A**ssumes that a cheap vaccine will become available in 2010, and that by 2014 all eligible persons will be vaccinated.
7) **Low progression rate to AIDS:** Considers an increase in the longevity of HIV-positive patients from 7 to 9 years, through a 45% reduction of the annual progression from HIV to full-blown AIDS.
8) **Combination of 4 and 6:** Medium behavioral change by 2020 and all persons vaccinated by 2014.
9) **Combination of 5 and 6:** High behavioral change by 2020 and all persons vaccinated by 2014.

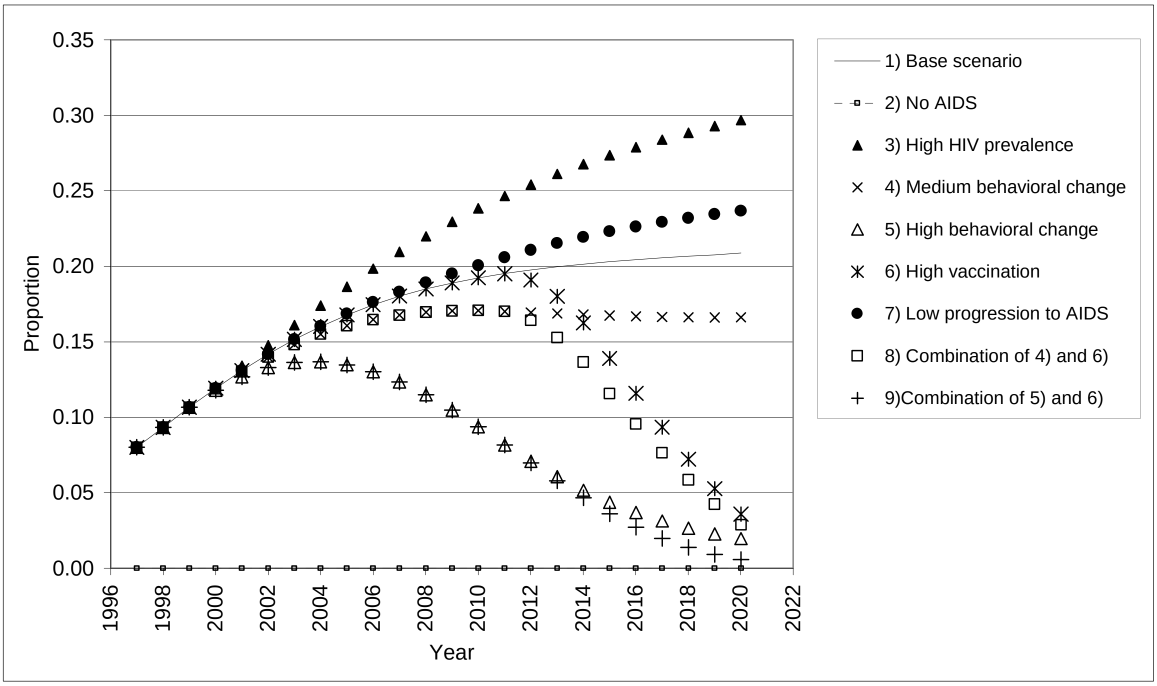
Scenario Results

The demographic impact of HIV/AIDS will be on the growth rate as well as on the age structure of the population. Like other sub-Saharan countries, Mozambique's growth rate is high, and the present age and sex structure is a wide-based pyramid with many young people and few elderly caused by high fertility and a gradual reduction of mortality. In the context of HIV/AIDS, this well-known pyramid shape will be altered. The fertility transition will be accelerated due to two effects. First, fertility reductions will be accelerated because HIV lowers fecundity by about 30%. Second, the reproductive lifetime of women who are infected will be shortened. Both of these effects mean the number of births will be reduced. On the other hand, mortality will rise, causing reductions in life expectancy. What are the demographic impacts of these trends in Mozambique? First, we discuss HIV prevalence, then population size and age structure, followed by mortality, life expectancy, and the number of births.

Prevalence

Policies against HIV/AIDS first impact prevalence, as shown in Figure 2. In the base scenario with low condom use, prevalence stabilizes at 20%. The scenarios with medium and high behavioral change immediately result in declining prevalence. With medium behavioral change, HIV prevalence stagnates at the lower level of 17%. If behavioral change is high (for example, high rates of condom use during risky sex), then the prevalence rate declines to less than 2% by 2020. These are important gains from raising behavioral change, such as condom use. The vaccine also lowers prevalence, but only after 2010, the presumed date of the introduction of the vaccine. The combination of high behavioral change and vaccine leads to the lowest prevalence (less than 0.5%) 20 years from now.

Figure 2. HIV prevalence rates among adults aged 15-49 in nine scenarios with HIV/AIDS.



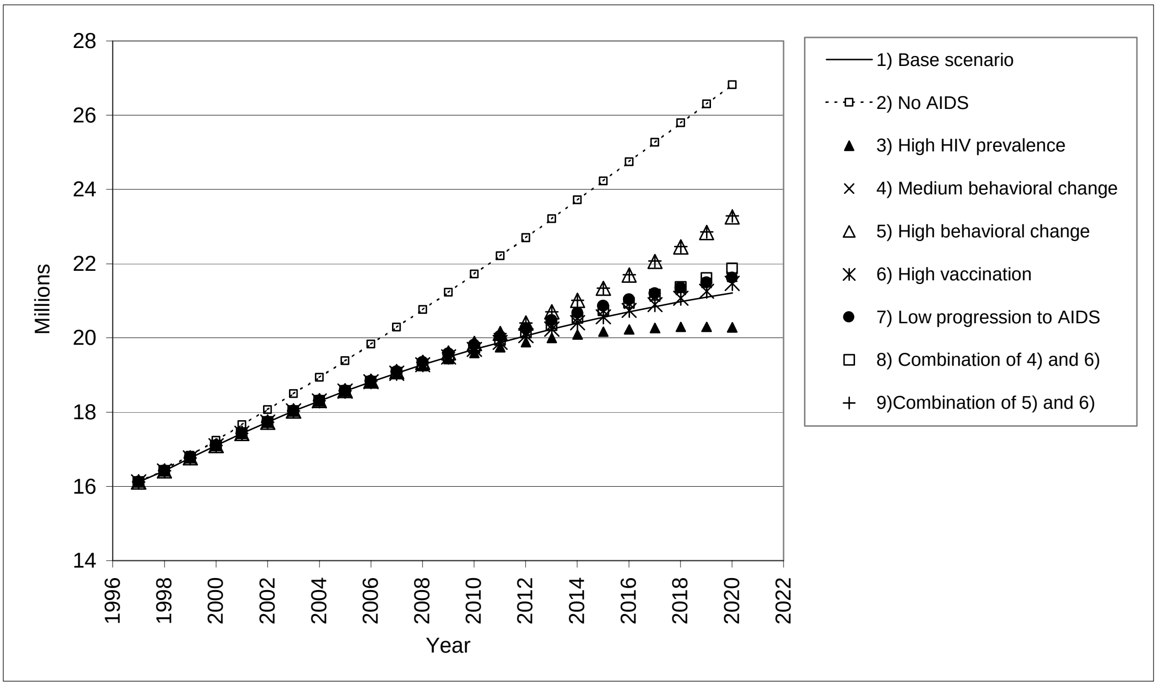
Population size

In Table 1 and Figure 3, we compare the population size projected by the scenarios described above. The effects of AIDS are already visible in 2001 in a lower population size than would have existed without AIDS. The table and figure show that without AIDS, the population would have risen to 17.2 million by 2000, and with AIDS, there are an estimated 16.2 million people.

Table 1. Population size according to nine HIV/AIDS scenarios (in millions).

Scenario	2000	2005	2010	2015	2020
1) Base scenario low behavioral change	17.10	18.57	19.69	20.56	21.21
2) No AIDS	17.24	19.38	21.72	24.23	26.82
3) High HIV prevalence	17.10	18.56	19.60	20.17	20.29
4) Medium behavioral change	17.10	18.57	19.73	20.73	21.65
5) High behavioral change	17.10	18.58	19.85	21.34	23.26
6) High vaccination	17.10	18.57	19.69	20.57	21.47
7) Low progression rate to AIDS	17.10	18.58	19.81	20.86	21.62
8) Combination of 4 and 6	17.10	18.57	19.73	20.74	21.87
9) Combination of 5 and 6	17.10	18.58	19.85	21.34	23.29

Figure 3. Population size according to nine HIV/AIDS scenarios.



The results show that policies to increase safe sexual practices must be taken today. By 2020, the highest population size is attained with the scenario that assumes high behavioral change (5), namely 22.3 million people as opposed to, for example, 21.2 million in the base scenario which assumes very little behavioral change (1). The alternative scenarios that consider treatment of the virus, namely, lower progression rates to full-blown AIDS (scenario 7) or a cheap vaccine (scenario 6) would raise the population size to 21.5 or 21.6

million, only 300,000-400,000 more than the base scenario by 2020. Given the conditions prevailing in Mozambique, these two scenarios are less effective than reductions of risky sex.

In the scenario with high prevalence (3) the population would be only 20.3 million by 2020, or 23% less than the most optimistic high behavioral change scenario (5). In this scenario, population growth becomes negative after 2010. Without AIDS (scenario 2), the population would rise to 27 million by 2020, which is 25% more people than the most pessimistic scenario (3), and 14% more than the optimistic scenario with high behavioral change (5). In other words, AIDS could reduce the population size by 14% to 25% in 20 years.

Population growth rates

Table 2 shows the population growth rates in the different scenarios. Over the next 20 years, population growth continues, with some fluctuations, in all scenarios except the most pessimistic (3). At present, growth is about 2% annually, and in the scenarios with high interventions, such as that with high behavioral change (5), the growth rates drop somewhat, but recover to the present rates by 2015 as the policies become effective.

Table 2. Population growth rates, 2000-2020, according to HIV/AIDS scenarios (in %).

Scenario	2000	2005	2010	2015	2020
1) Base scenario low behavioral change	1.95	1.46	1.02	0.78	0.52
2) No AIDS	2.35	2.30	2.28	2.13	1.96
3) High HIV prevalence	1.95	1.41	0.87	0.40	-0.05
4) Medium behavioral change	1.95	1.46	1.12	0.97	0.79
5) High behavioral change	1.95	1.46	1.27	1.56	1.82
6) High vaccination	1.95	1.46	1.02	0.78	0.98
7) Low progression rate to AIDS	1.95	1.46	1.17	0.92	0.60
8) Combination of 4 and 6	1.95	1.46	1.12	0.97	1.20
9) Combination of 5 and 6	1.95	1.46	1.27	1.56	1.86

In the most pessimistic scenario, population growth rates turn negative by 2020. The rate of negative growth accelerates from -0.5% annually. Countries such as Zimbabwe, Botswana, Namibia, South Africa, Swaziland, Malawi, and Zambia also have seen their growth rates reduced by HIV/AIDS. By 2003, the population in Botswana, South Africa, and Zimbabwe is expected to decline by -0.1% to -0.3% (Stanecki 2000). This is the combined result of high death rates from AIDS and fewer births due to HIV/AIDS.

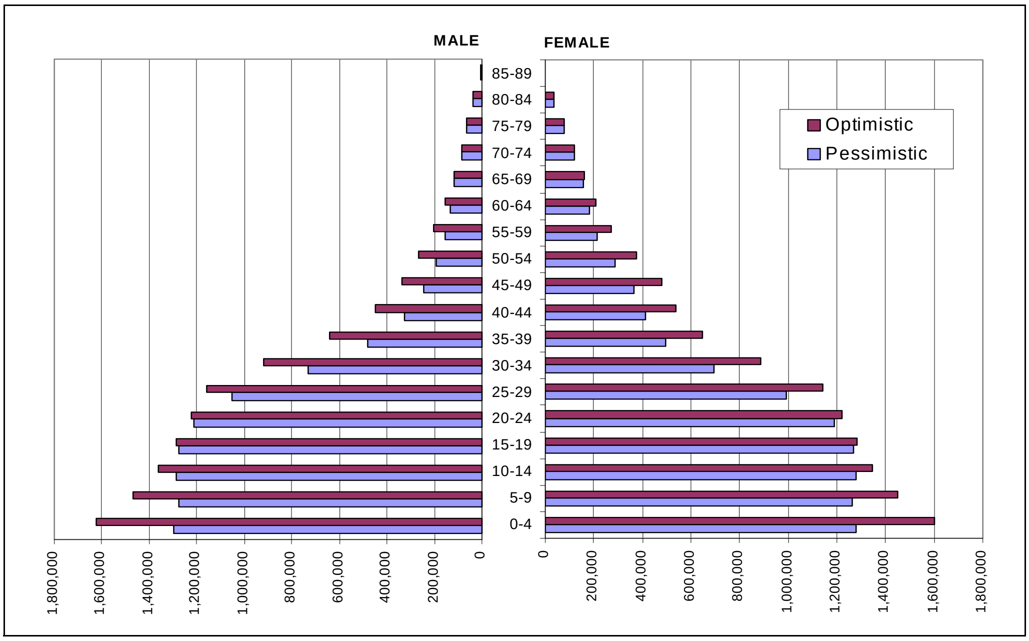
The highest population growth rates for Mozambique are projected in the scenario without AIDS (2), which reproduces the official population projections. For example, without AIDS, population growth would still be 2.4% annually by 2020, as opposed to 1.7% annually in the optimistic scenario with high behavioral change (5).

Age composition of the population

The impact of AIDS is not uniform for all ages, and as a result, the age pyramids of countries with high HIV prevalence rates will attain a form never before seen. By 2020, there will be more men in the age groups 15-44 in South Africa, Botswana, and Zimbabwe, due to the higher infection rates of young women.

To facilitate the analysis of age structure, we use two scenarios, namely, scenario 5 with a relatively low spread of HIV prevalence and high behavioral change by 2020 (optimistic) and scenario 3 with HIV prevalence rates rising to 30% by 2020 (pessimistic). The results, shown in Figure 4, will lead to significant alterations in the population age structure. The pyramids speak for themselves.

Figure 4. The age pyramid in 2020 according to two scenarios, optimistic (high behavioral change and low spread of HIV) and pessimistic (high spread of HIV and no behavioral change).



The impact of AIDS will be differentiated by age but will be similar for men and women. This is because the model does not differentiate the infection rates for men and women, although it is likely that as in other countries, the infection rates among women are higher than those among men. Bearing this simplification in mind, let us turn now to the results.

The effect of AIDS will be most severe among children due to the reductions in births and deaths of young children and infants from AIDS, and among adults aged 30-64. In 2020, according to the pessimistic scenario, the population aged 0-14 could be 32% to 45% lower (depending on the age group) and among those aged 30-64, the reductions would be 46% to 65%. In the optimistic scenario, the losses are 22% to 23% and 14% to 37%, respectively.

AIDS deaths

The first case of AIDS was diagnosed in 1986 in Mozambique. Since then, the number of deaths from AIDS has progressively increased. In 2000, AIDS caused an estimated 84,000 deaths. In many countries of sub-Saharan Africa, life expectancy has already dropped as a result of AIDS. In Botswana, life expectancy in 1999 was 39 years instead of the 71 it would be without AIDS. In Zimbabwe, life expectancy was 38 instead of 70. The rise in AIDS deaths has already reduced life expectancy in Mozambique. Today, life expectancy is 43 years, instead of the 45 it would be without AIDS. In the long run, life expectancy could be reduced even more. For example, by 2020, life expectancy in Mozambique could be 9-24 years lower than in the case of no AIDS (9 with high behavioral change and vaccine, 24 in the pessimistic scenario with high prevalence rates).

Table 3 shows the AIDS deaths in Mozambique as calculated by the scenarios. There are quite considerable differences. In the base scenario with continued low behavioral change but also a slow spreading of the virus, deaths would rise to 278,000 in 2020. This number could be 372,000 in the pessimistic scenario. High behavioral change alone would lower the death rate to 46,000 in 2020, saving more than 200,000 lives each year. The addition of the vaccine would take away an additional 14,000 deaths.

Table 3. AIDS deaths in Mozambique from 2000-2020 according to the scenarios.

Scenario	2000	2005	2010	2015	2020
1) Base scenario low behavioral change	60,489	142,188	209,062	252,915	277,792
2) No AIDS	0	0	0	0	0
3) High HIV prevalence	60,489	144,763	237,305	318,959	372,028
4) Medium behavioral change	60,489	141,394	197,702	220,633	227,688
5) High behavioral change	60,489	138,523	157,190	104,745	46,221
6) High vaccination	60,489	142,188	209,062	249,928	168,574
7) Low progression rate to AIDS	60,489	138,823	191,410	235,844	270,329
8) Combination of 4 and 6	60,489	141,394	197,702	218,158	138,670
9) Combination of 5 and 6	60,489	138,523	157,190	104,342	32,988

As mentioned above, the incubation period of HIV is presently about 7 years in Mozambique. With the progression rates 45% lower than the present ones, the period of incubation would be extended from 7 to 9 years. As a result, for adults, AIDS deaths would occur on average 10 years after the infection. However, this does not have a big impact on the number of AIDS deaths. With the low progression, there would be 270,000 deaths in 2020 as opposed to 278,000 in the base scenario. The reason for this small effect is because if people with HIV live longer, they can infect more people. Therefore, a policy that lengthens the HIV incubation period, which is imperative on humanitarian grounds, should always be combined with policies to reduce infection, such as higher behavioral change.

Births

AIDS affects the number of births through the reduction of fecundity and the number of child-bearing years among HIV-positive women. A lower number of births, resulting from HIV/AIDS, is a significant contributor to slower population growth.

The effect of AIDS on the number of births is shown in Table 4. As described above, in the optimistic scenario, prevalence declines from 13% in 2000 to 2% in 2020 due to higher rates of behavioral change. In the pessimistic scenario, the HIV prevalence rate rises to 30% by 2020. The effect on the number of births shows the two HIV effects on births. There are more births in the optimistic scenario than in the pessimistic because of the younger population age structure and higher fecundity.

At present, 2% of all births are HIV positive. By 2020, this figure could rise to 7% in the pessimistic scenario and fall to under 1% in the optimistic scenario. Infants who are born with HIV generally have a life expectancy below two years, because they develop full-blown AIDS more quickly than adults.

Table 4. Number of births according to the optimistic (5 – high behavioral change) and pessimistic (3 – high HIV prevalence and no behavioral change) scenarios.

	2000	2005	2010	2015	2020
Total number of births					
3) Pessimistic	714,719	702,561	679,453	638,313	581,881
5) Optimistic	715,226	714,758	723,785	740,537.5	748,820.2
Total HIV-negative births					
3) Pessimistic	695,393	672,639	641,773	597,771	541,627
5) Optimistic	696,242	693,296	709,481	734,355	746,073
Total HIV-positive births					
3) Pessimistic	16,105	24,935	31,400	33,785	33,545
5) Optimistic	15,820	17,885	11,920	5,152.05	2,289.35
Total AIDS births					
3) Pessimistic	3,221	4,987	6,280	6,757	6,709
5) Optimistic	3,164	3,577	2,384	1,030	458
Proportion of HIV-positive births					
3) Pessimistic	2.70%	4.26%	5.55%	6.35%	6.92%
5) Optimistic	2.65%	3.00%	1.98%	0.83%	0.37%

Conclusions

From a demographic point of view, in the short run, the impact of AIDS will not be significant. Up to now, AIDS has had only a marginal effect on the age and sex structure of the population, and on the pattern of mortality. In the long run, if HIV prevalence continues to expand, the size and structure of the population will be radically altered, particularly in those regions of the country most exposed to high risk and with few means to deal with the epidemic. By 2020, population size in Mozambique could be 14% to 25% smaller than without HIV/AIDS. The population age structure could be significantly modified from the traditional wide-based pyramid. The biggest change will be visible in the age groups 0-14 and 30-64, which are the most affected by the HIV/AIDS epidemic. Because HIV/AIDS affects children as well as adults, the epidemic will have little impact on the dependency ratios.

HIV/AIDS will also affect life expectancy. By 2020, life expectancy could be between 32 and 50 years for men, compared to 53 without the epidemic, and 32 to 53 years instead of 56 for women.

The damaging impact of HIV/AIDS can be significantly reduced if large proportions of the sexually active population were to begin today to change their behavior, for example, by using condoms during risky sexual encounters. If behavioral change reduced incidence rates by 80% by 2020, HIV prevalence in that year would be only 2%. Population size would still be 20% lower than without the epidemic, because many AIDS deaths are already built into the present HIV prevalence structure, and because we assume that behavioral change increases only gradually. In the worst case, with high transmission rates and no rises in behavioral change, the population might be 39% less than without the epidemic and declining by 2020.

Policies to reduce the impact of HIV/AIDS should include programs of information and communication. The data from the Demographic and Health Survey 1997 show that 94% of adult men and 82% of adult women in the reproductive ages have heard of AIDS. Although there is widespread knowledge of the disease, this cannot be said with regard to knowledge of how to prevent HIV infection. More than one-third of those questioned said there was no way to avoid AIDS; more than 20% did not change their sexual behavior in spite of knowledge of AIDS. These numbers show that public information programs that educate people on the risks of AIDS and ways to prevent it, are imperative as well as messages to modify sexual behavior.

Even if a wholly effective and cheap vaccine were discovered within the next decade, our simulations show that policies to promote behavioral change are still the better option because they can be implemented immediately, and could be made accessible to all of the population.

Finally, it should be mentioned that the accuracy of the population projections for Mozambique will depend on the quality of the available data, in particular, the information on HIV prevalence.

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YOUNG ENTRANTS STAY IN SCHOOL LONGER: EXAMPLE FROM MOZAMBIQUE

Annababette Wils and Manuel da Costa Gaspar

Introduction

The investigation that led to this paper arose out of two conundrums concerning school enrollment and dropout data in Mozambique. First, according to recent statistics compiled by the Ministry of Education, only 87% of the pupils in elementary school proceeded from one grade to the next, or 13% dropped out at each level. However, information from the 1997 population census showed that of the children who attended school sometime between the age of 5 and 13 – generally in the elementary grades – only 13% had left school. How can the high drop out rates given by the Ministry of Education be reconciled with the low drop out rates found in the census? A detailed analysis of the school entry and departure patterns, using school enrollment data from the Ministry of Education, and statistics on school attendance from the 1997 population census show that a likely explanation is heterogeneity by age with respect to school departure. Those who enter school at a young age experience lower drop out rates than older entrants. Second, information from the schools showed a much higher entry rate at young ages than the census. An analysis shows that it is likely that pupils or teachers under-report the age of first and second grade pupils, perhaps for reasons of school access or politics.

For the analysis of school drop out, school entry, grade promotion, repetition, and departure were reconstructed over the period 1983-1997 with age-constant drop out and age-differentiated drop out. The reconstruction with substantially lower drop out rates for young entrants and higher drop out for older school entrants reconciled the high drop out per grade with low drop out by age in the pre-teen years. It also reproduced the 1997 age-specific enrollment curve and the number of pupils. According to the approximations, students who entered school in 1997 between the age of 5 and 7 can expect to finish 6.9 grades of school, compared to 4.7 for those who enter at ages 8-10; 3.3 for entrants aged 11-14; and only 1.7 for those who enter later than age 15.

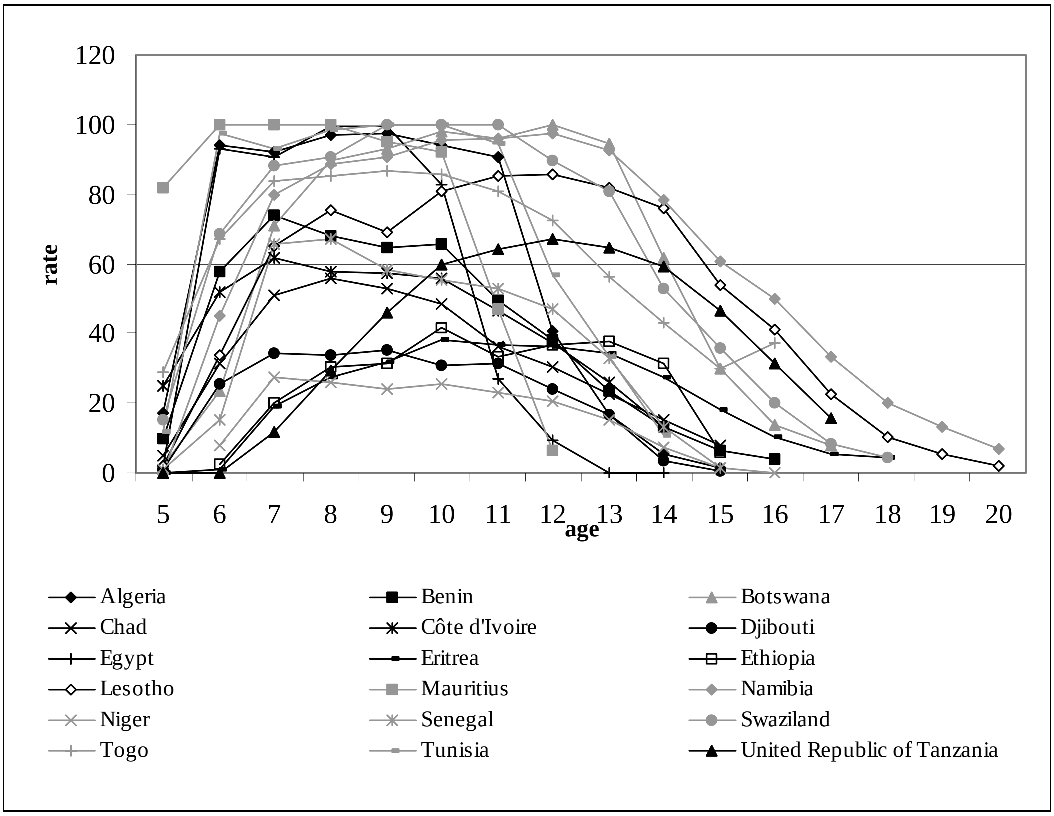
Delayed school entry has received little attention in the literature, but the results show that this is unjustified, given its deleterious effect on school outcome. While we did not duplicate the calculation for other countries, we believe it is not unlikely that a similar situation prevails in other countries, which are similar to Mozambique, in that late school entry is common.

It is plausible that early entry might lead to longer school enrollment. Parents who send their children to school as soon as possible might be more motivated about education in general, and be able to afford the time and financial investments to see their children through a long enrollment period. Older children, in particular teenagers, are more likely than younger children to have conflicting responsibilities within the household or at work. Some of the causes of late entry might also cause early departure. For example, Caldwell (1967) suggested that children who have a long walk to school might not be able to attend until they are older. At the same time, the long distance would also be a reason for pupils to drop out. In Mozambique in 1997, 18% of the population was more than 5 kilometers away from a primary school. Almost all (89%) were more than 5 kilometers away from a secondary school (Ministério do Plano e Finanças et al. 1997). Another reason a child might enter school late is because parents can only afford to send their children to school sequentially, meaning a child might first have to wait his or her turn, and then must give way to the next in line.

Late School Entry in Africa

Late school entry is pervasive in Africa (Lloyd and Blanc 1996; UNESCO 2001). Figure 1 shows age-specific enrollment in 18 African countries in 1996. If all children enter at the official school intake age, there is a short, sharp rise in enrollment at that age. There are only four countries where this is the case: Egypt, Tunisia, Algeria, and Mauritius, none of which is in continental sub-Saharan Africa. In the other countries in the figure, enrollment rises gradually with age, starting from age 5 and continuing up to age 8, or as high as age 12 in Tanzania and Lesotho. A rising enrollment rate by age means that people are still entering school. But even where the enrollment rate is flat from one age to the next, there is often a flux of pupils, with some departing and some entering school.

Figure 1. Primary enrollment rates in 1996 for African countries where data was available from UNESCO. Source: www.unesco.org.



Another indicator of late entry is the ratio of the *apparent intake rate* and the *net intake rate.* The apparent intake rate equals the total number of new entrants in the first grade of primary education, regardless of age, expressed as a percentage of the population at the official primary school entrance age. The net intake rate equals the total number of new entrants in the first grade of primary education of the official primary school entrance age, expressed as a percentage of the population at the official primary school entrance age. If the apparent intake rate is higher than the net intake rate, this implies late school entry (barring the unlikely case that many children enter school before the official school entrance age). Table 1 shows the 1996 apparent intake rate, net intake rate, and the ratio for seven African countries where the data was available from UNESCO. The highest ratios are found in Lesotho (3.4), Eritrea (2.9), and Swaziland (2.1). Figure 1 confirms that these are indeed countries where enrollment increases by age until age 9 or higher.

Table 1. Apparent intake rate, net intake rate, and the ratio apparent:net intake for seven African countries in 1996 for which the data were available from UNESCO. Source: www.unesco.org.

Country	Apparent intake rate	Net intake rate	Ratio apparent:net intake rates
Algeria	100.8	77.3	1.30
Eritrea	42.3	14.5	2.92
Lesotho	102.6	30.2	3.40
Mauritius	110.1	82.2	1.34
Niger	31.6	19.3	1.64
Swaziland	115.2	54.6	2.11
Tunisia	101.7	87.8	1.16

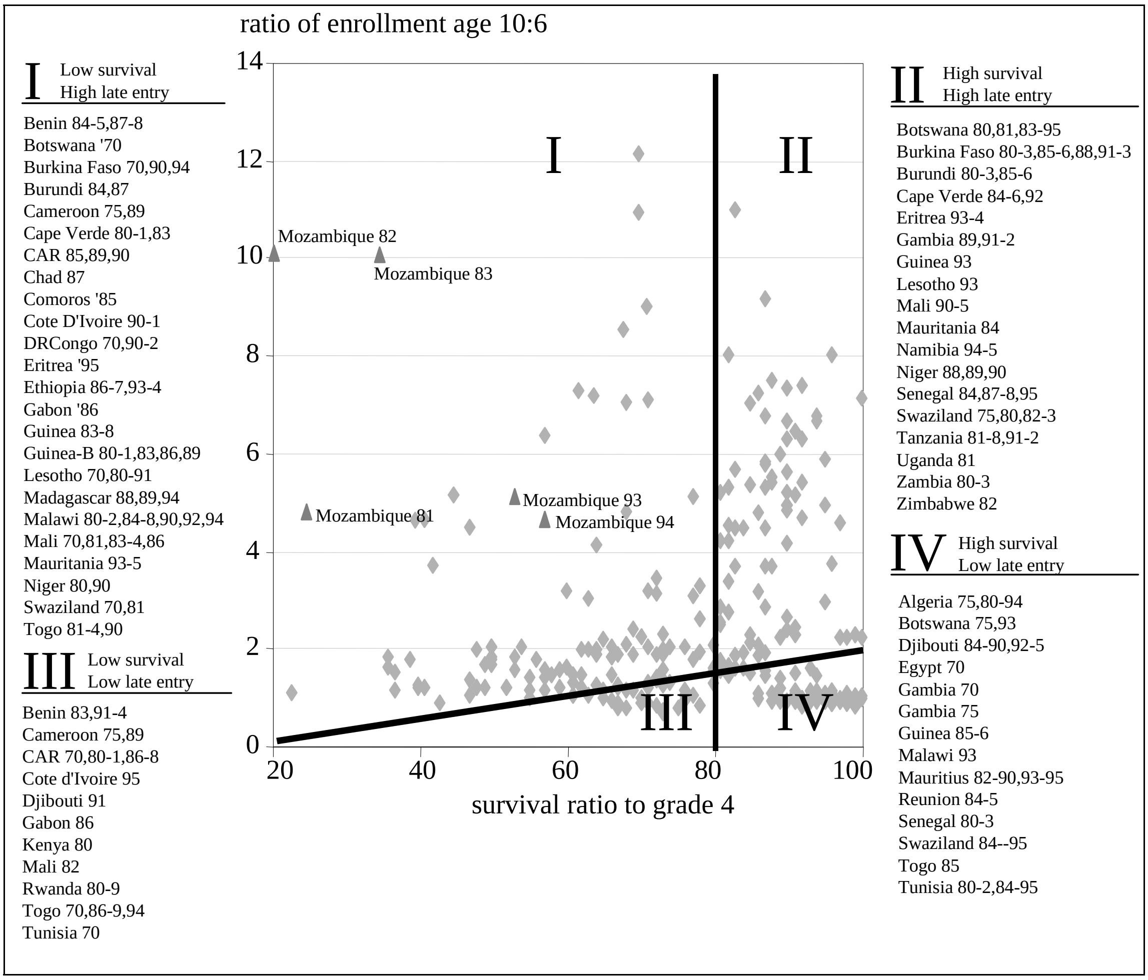
If late entry leads to higher drop out rates, then there should be a negative relationship between late entry and overall school performance. One expression of this relationship could be that the more late school entry prevails, the larger the ratio of enrollment at age a:a+x, compared to the *survival ratio to grade x*.[4] If there is no late entry and survival to, for example, grade 4 is 50%, then assuming that the common official school entry age is 6, the ratio of school enrollment at age 10:age 6 is 0.5. If there is late entry, and survival to grade 4 is 50%, then the ratio of enrollment age 10:age 6 would be higher than 0.5, because, although half of the children who started school at age 6 have dropped out by age 10, the other children who entered school later replaced them. Repetition will tend to inflate the ratio of enrollment at age a:a+x, and there are confounding effects of changes in school entry and school retention over time.

Figure 2 plots school survival to grade 4 against an enrollment age of 10:6 for countries in Africa, 1970-1995. In those countries where the official school entry is age 7, the ratio for age is 11:7. There are 291 pairs for 39 countries available from UNESCO. The diagram is divided into four areas with the possible combinations of low or high survival and low or high late entry. Area I contains survival ratios below 0.8 and enrollment ratios age 10:6, which are more than twice as high as the survival ratio, indicating late entry. There are 24 countries, which were in this area in the period 1970-1995. Mozambique, which is in this area, is highlighted with distinctive markers and labels. In the beginning of the 1980s, Mozambique was an outlier with extremely low survival ratios and very common late entry. The two more recent points, for 1994 and 1995, indicate that the country is now within the

[4] Survival ratio to grade x = Percentage of a cohort of pupils enrolled in the first grade of a given level or cycle of education in a given school year who are expected to reach grade x. Calculation method provided in www.unesco.org under Statistics.

realm of more common experience. Area II has high survival ratios above 0.8 and also high late entry. There are 18 countries in this area, including Botswana and Burkina Faso, for which a long time series was available. This shows that late entry can be combined with good to complete retention. One implication for further study would be to identify the circumstances in these countries that allow late entrants to stay in school. Area III with 11 countries has a low survival ratio and low late entry. Area IV shows high survival and low late entry in 14 countries. In 13 of these 14 countries school is nearly universal. In Djibouti, enrollment by age never reaches 40%. Because there are shifts in school experience over time, some countries are in more than one area, depending on the year. It is most common for countries to be in both Areas I and II, with consistent late entry but variable grade survival.

Figure 2. Scattergram of the ratio of school enrollment age 10:age 6 (or age 11:age 7, if official school entrance is age 7) and survival to grade 4.



The figure shows that in Africa, countries run the gamut with regard to possible experiences for late school entry and grade survival. In some countries most children reach grade 4, but many enter school late (Botswana); in Mauritius and the North African countries, children enter school at age 6 and most of them reach grade 4. However, in many sub-Saharan countries, there is combined low survival and late entry.

From the figure we conclude that while the combination of late entry and poor school performance is not universal, it is common. The combination could be the result of a weak school system overall, and/or school survival heterogeneity, where late entrants have lower survival rates. Our analysis indicated the latter for Mozambique.

School Attendance Data from Mozambique

We turn now to the case study on Mozambique, which allows a much more detailed investigation of late school entry and school survival. For our analysis, we use the 1997 census. Mozambique is a large country emerging from a long period of war, with a rapidly expanding school system. In 1992, when the Peace Agreement was signed, there were 1.3 million pupils in primary school; by 2000, there were 2.5 million. Relatively speaking, school entry has increased even more. In 1992, 267,000 students entered first grade; in 1995, 349,000; and by 2000, 582,000. The country has been building an average of 500 new schools annually since 1992, and there are now approximately 7,300 primary schools. Still, the country's education profile is similar to that of many other poor countries in Africa. Net and gross primary enrollment rates were 0.43 and 0.74, respectively, in 1997, although by 2000, gross enrollment had increased to an estimated 0.91 (data made available by the Ministry of Education, Maputo). As in many sub-Saharan countries, school entry is delayed (Lloyd and Blanc 1996), although at present, it is probably close to complete. There are high drop out rates for each grade.

Data sources

The analysis uses two data sources: 1) the 1997 population census conducted by the Instituto Nacional de Estatística; 2) school enrollment and repeaters by grade and sex, collected from schools by the Ministry of Education.

In almost all countries, Ministries of Education or related institutions provide annual statistics on school enrollment, namely, children in each grade and repeaters. From these data, indicators, such as the gross enrollment rate,[5] net enrollment rate,[6] intake rates, school survival, and school life expectancy are calculated.[7] In addition, census data, collected at larger intervals, contain valuable information about school attendance.

What can a population census provide that is new? A census collects information on school participation from the household rather than the school, and so is a "reality check". A census also provides the correct (or more correct) base population for the calculation of rates. It provides information that is otherwise unavailable, namely, on people who are *not* in school. A census might ask: of those who are not presently in school, what is the highest grade completed? Or on a more basic level, whether the person in question never attended school, or did attend school, but left. The latter piece of information, if provided by age,

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[5] Gross enrollment rate – Total enrollment in a specific level of education, regardless of age, expressed as a percentage of the official school-age population corresponding to the same level of education in a given school year (definition taken from http://unescostat.unesco.org/en/stats/stats0.htm).

[6] Net enrollment rate – Enrollment of the official age group for a given level of education expressed as a percentage of the corresponding population (definition taken from http://unescostat.unesco.org/en/stats/stats0.htm).

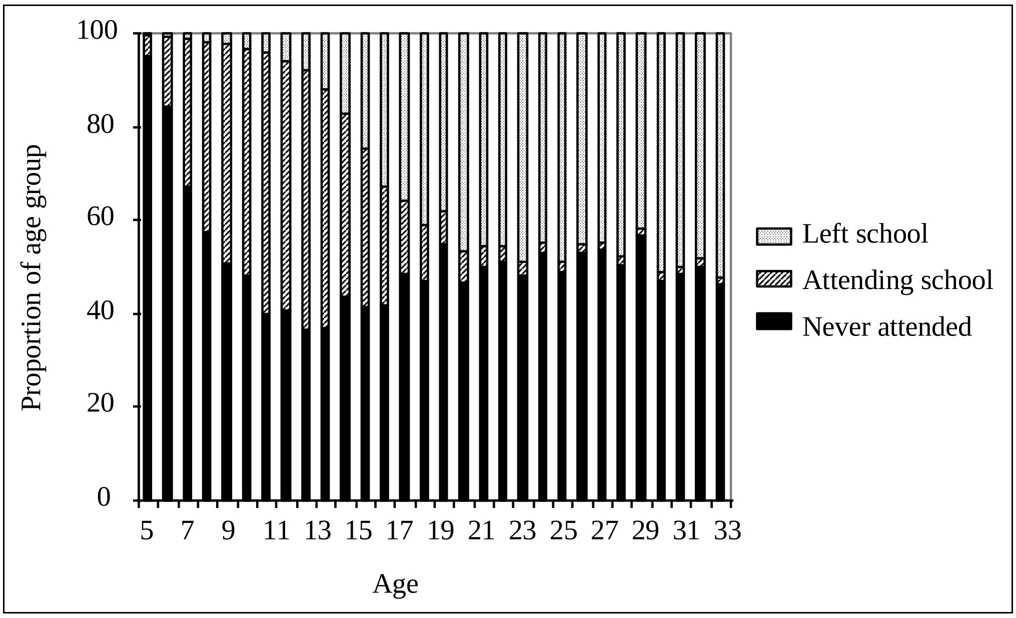
[7] See for example, www.unesco.org for an extensive global collection.

allows an estimation of age-specific drop out rates, which are not normally available from the annually-collected, published data.

Census data

The basic census data for our analysis gives information on the number of people who 1) are presently attending school, 2) have left school, and 3) have never attended school, by single year age groups from 5-34. The *proportions* of each age group in these three categories are shown in the bars of Figure 3. The figure shows that in 1997, at age 5, almost no one had ever attended school, and only a small portion was presently in school. The proportion that never attended school is generally lower for each consecutive age group until age 13, as more and more people enter school. At age 13, only 37% never attended school. The *gradual* decline in the proportion of those who never attended school signals that children begin school at various ages, ranging from age 5 to age 13. After age 13, we see that the proportion that never attended school rises. At age 19 and higher, about 50% never attended school. The high proportions of people who never attended school at age 19 and above reflect the low levels of school enrollment during the civil war, when these people were of normal school age. Also, in general, the proportion that has left school gradually takes up more of each bar, as with each consecutive age group a larger portion has quit school. There are a few fluctuations within the general pattern. In section 0, school intake and school drop out rates by age are calculated with this data.

Figure 3. Proportion of people in Mozambique in 1997 who never attended school, are presently in school, and left school, by one year age groups, ages 5-34. Source: Instituto Nacional de Estatística (1999).



School data

The relevant information from the Ministry of Education is collected annually from all schools. The schools provide information about the number of pupils by grade, age and year, the number of repeaters, and the number of teachers and classrooms. We obtained the total pupils and repeaters, per grade and sex, for 1992-1995 and 1998-2000 (the latter three years also by province), and the total number of pupils by age and grades 1-5 in 1997 and 1998 (unpublished data) thanks to the generosity of the Ministry of Education. From these data, we can calculate promotion rates, repetition rates, and the drop out rates in the earlier of the two years. The promotion rates equal:

$$\frac{\textit{First time in grade}^{\ year2,grade\ x+1}}{\textit{Enrolled}^{\ year\ 1,grade\ x}} \qquad 1)$$

The repetition rates equal:

$$\frac{\textit{Repeaters}^{\ year\ 2,\ grade\ x}}{\textit{Enrolled},^{\ year\ 1,grade\ x}} \qquad 2)$$

The drop out rates are:

$$\frac{\textit{Enrolled}^{\ year\ 1,grade\ x} - \textit{Repeaters}^{\ year\ 2,\ grade\ x} - \textit{First time in grade}^{\ year\ 2,\ grade\ x+1}}{\textit{Enrolled}^{\ year\ 1,\ grade\ x}} \qquad 3)$$

A numerical example is given in Table 2. In 1999, the promotion rate from first grade to second was 420,689/708,120 = 0.59; repetition in first grade was 190,558/708,120 = 0.27; and drop out was 0.14 for males and females taken together.

Table 2. Example for the calculation of promotion, repetition and drop out rates using 1999 and 2000 data for first and second grade.

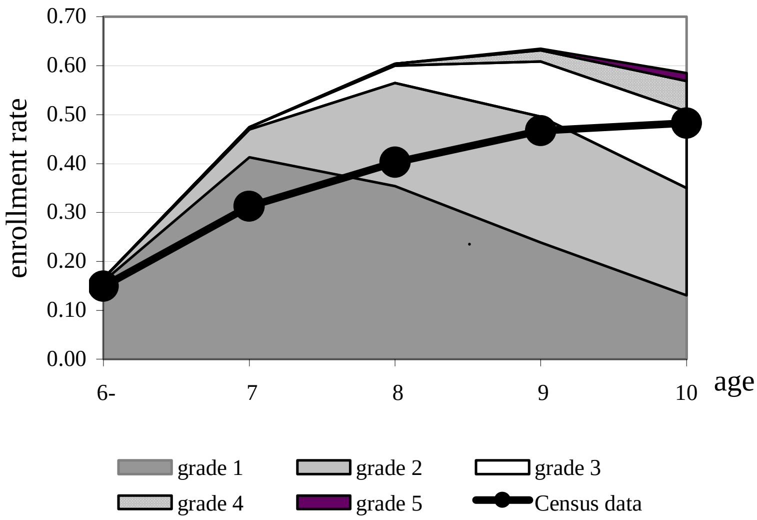
Year	Classification	Grade 1	Grade 2
1999	Enrolled	708,120	514,996
	Repeaters	190,558	127,066
	First time	517,562	387,930
2000	Enrolled	770,977	551,764
	Repeaters	190,558	131,075
	First time	580,419	420,689
	Drop out	96,873	

Compatibility of data

The two data sources agree on the number of pupils in elementary school. According to the information collected by schools, there were 1.919 million students enrolled in primary school in March 1997 (first and second level) compared to 1.900 million counted by the census in August 1997. However, there are differences in the age structure of the pupils. Figure 4 shows pupils aged 6-10 according to the two data sources. Clearly, the schools show a younger pupil age structure than the census data. At age 7, for example, according to the school data, the age specific enrollment rate is 47% compared to 31% found during the census. On the other hand, the school data show age specific enrollment declining beyond age 10; the census data does not.

One possible explanation for the difference is that children who enter school under-report their age in order to be accepted (or school officials say their first and second grade pupils are younger than they really are), while during the census count, age reporting was more correct. Another discrepancy, discussed later, is in school retention. The drop out rates in each grade of primary school, according to calculations made with the school data, ranged from 9% to 35% in the period 1995-1999. However, according to the census data, only 10% of those who entered school left by the time they were 13 years old, meaning that there was high retention at the young ages, which filled many of the primary school classes.

Figure 4. Elementary school pupils by age 6-10 according to information collected from schools and by the 1997 population census. Data from schools shown disaggregated by grade. Sources: Population census CD-Rom and school data provided by the Ministry of Education.



School Intake

In a school system such as that of Mozambique, children and adults enter school at a wide range of ages, and drop out occurs at every age group. Both the school information and the census can be used to estimate of the age pattern of school entry.

To obtain a rough estimate of the age-specific school entry pattern from the census, we look at the differences in the proportions of those who never attended school from one age to the next. We need to adjust for the fact that enrollment was increasing rapidly by about 9% in 1997 (about 4 percentage points are simply a result of increasing age group size). The estimated proportion starting school at age *a* is:

$$s_a=n_a-n_{a-1}(1-.05), \qquad 4)$$

where n is the proportion who never attended school, age is a and s represents the school starters.

From the schools, we have pupils in first grade by age, but need to subtract the repeaters, in order to obtain the entrants. Overall repetition is 0.27 in the first grade, but might differ by age. The number of pupils who started first grade in any given year, by age, is:

$$s_a=E_{1,a}*(1-r_{1,a})/P_a, \qquad 5)$$

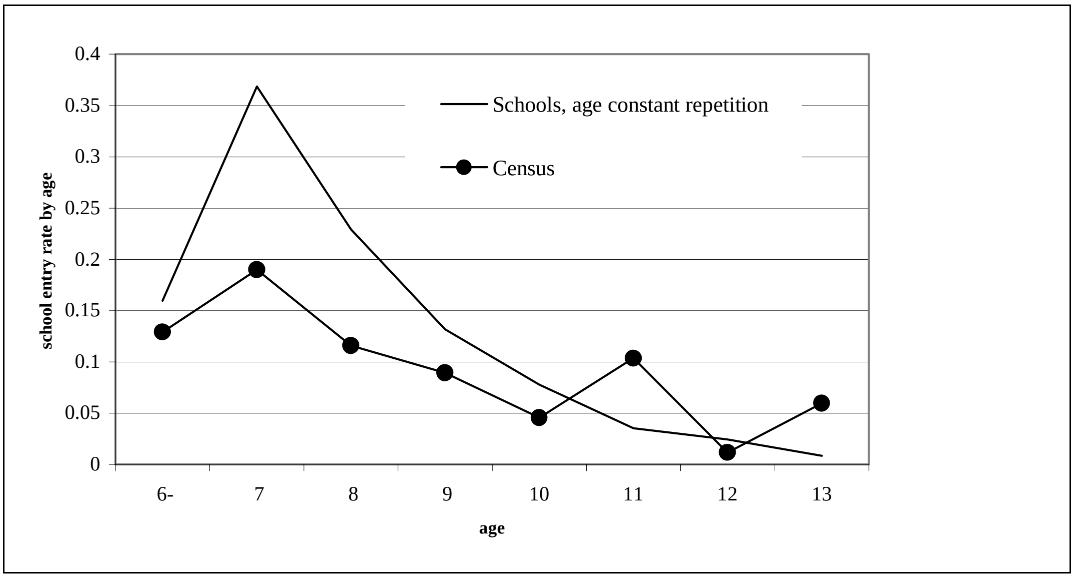
where $E_{1,a}$ is the number of pupils enrolled in grade 1, age is a; $r_{1,a}$ is the repetition rate for grade 1, and P_a is the population at age a.

Figure 5 shows the estimates for school entry rates by age from the above calculations. Both sources agree that the highest rates of school entry are at age 7, but not on the level. According to the census data, about 19% of the 7 year olds entered school in 1997, compared to an estimated 36% according to the school data. Furthermore, according to the census, there was still substantial school entry in the early teen years, whereas the school data show entry tapering off towards zero. The difference explains almost all of the overall enrollment rate discrepancy. Hypothesis 1 arose from this comparison:

H1: Pupil age reported in grade 1 and possibly 2 is often lower than the actual age.

The analysis of school drop out in the next section confirms this hypothesis.

Figure 5. Estimated school entry in 1997 by age, according to calculations with school data and with census data. Age constant repetition in grade 1 = 0.27 regardless of age.



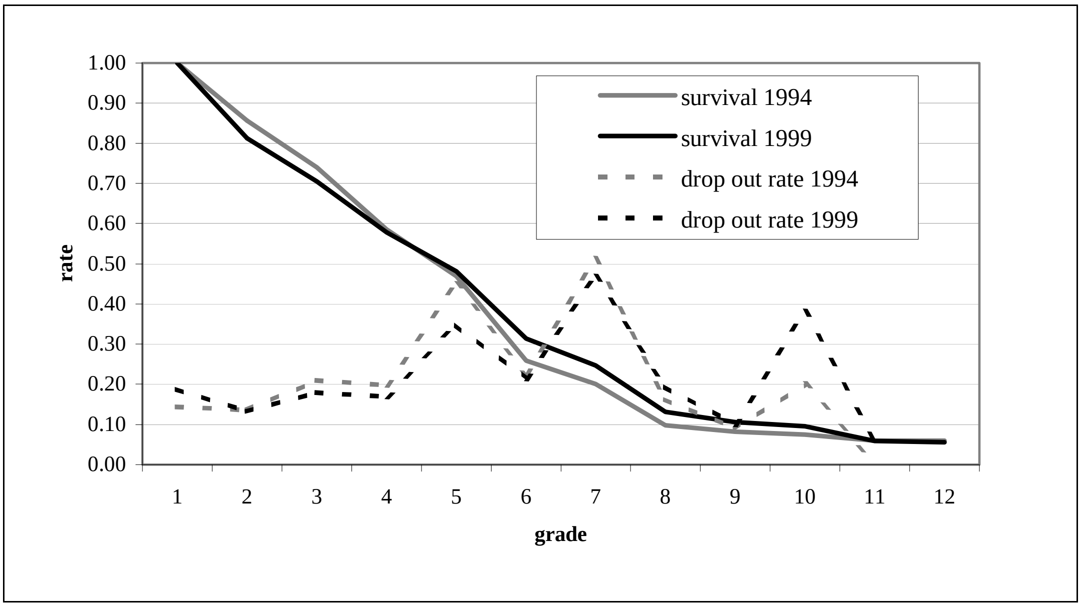
School Retention and Drop Out

Drop out by grade: School data

Legare (1972) developed the method to calculate a synthetic cohort survival by grade, which is the basis for all of our survival and drop out calculations, and which is the method used by UNESCO. The survival to grade x is a quasi-lifetable, which gives the *expected number of* *grades completed*[8] under present promotion, repetition, and drop out rates. The original method does not differentiate by age, but rather, treats all entrants as one group. The spreadsheet with which one does the calculations is shown in Appendix Table A.

With this method, one can calculate the school survival curves – the proportion of original entrants who reach grade *x*. The survival curves for 1994 and 1999 are shown in Figure 6. Both of the curves are very similar. There is a somewhat higher survival rate in 1999 at grade 6 and above (those school levels higher than basic primary). This means that in spite of the rapid expansion, the school system has been able to maintain the same level of efficiency,[9] which is an extraordinary achievement. The retention from grade 1 to 2 in 1999 was 81%. Only 71% of those who start school reach grade 3; 48% finish the lower primary level grade 5; and a mere 6% would complete the whole 12 grade school cycle with the 1999 retention and repetition pattern. In terms of drop out rates, this means that in first grade, a total of 19% of the first graders left school in 1999; 13% of the second graders; 18% of the third; and 17% of the fourth graders. The dotted lines in the figure show the corresponding 1994 and 1999 drop out rates in each class. In the lower grades, the overall drop out level ranges from 13% to 20%. There are clear spikes at grade 5, 7 and 10, the transition grades from one school level to the next.

Figure 6. Grade specific school survival and drop out, starting with a cohort of 100 at grade 1, using 1994/1995 and 1999/2000 enrollment data from the Ministry of Education.



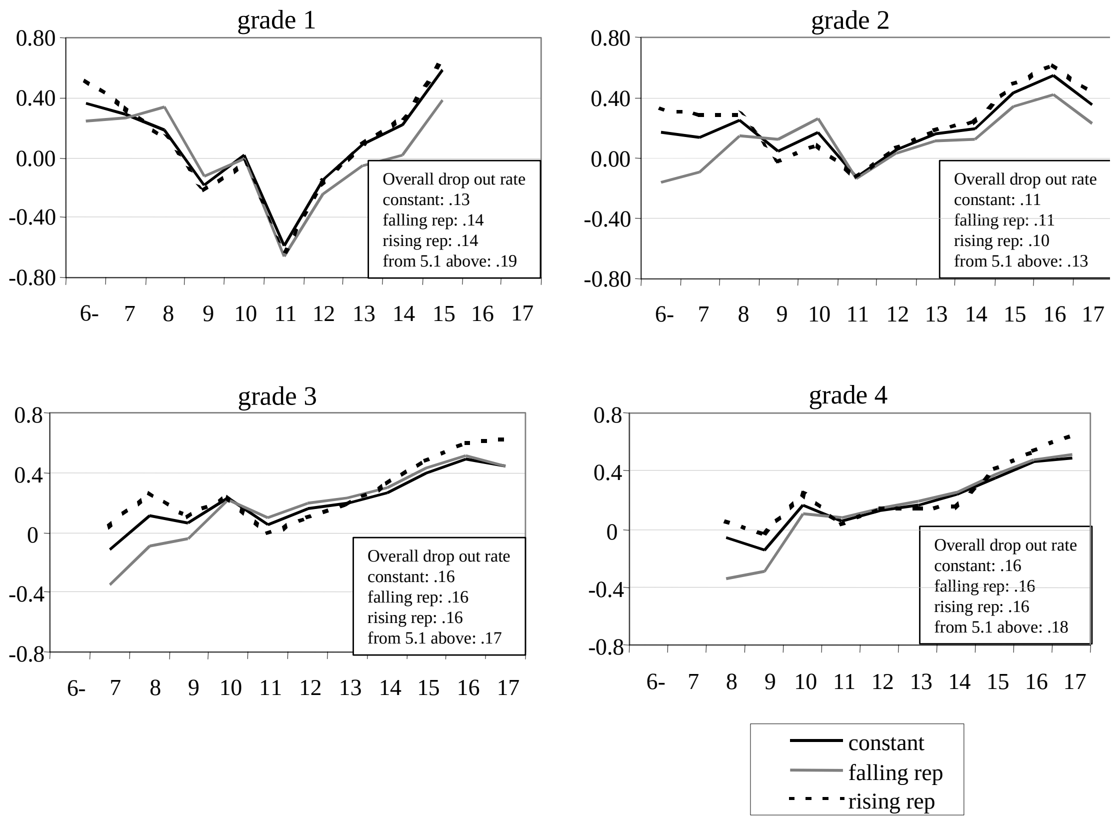
[8] Grade expectancy to grade *x* = the number of grades a pupil who enters school can expect to complete if the present promotion, repetition, and drop out rates prevail throughout the pupil's enrollment. Calculated as the sum of survival ratios to grade *x*. Primary grade expectancy includes only primary school enrollment. Overall grade expectancy includes primary and secondary enrollment up to grade 12.

[9] During a previous period of rapid expansion, in the early years after independence, there was a significant loss of efficiency as school intake levels expanded, according to the data provided on the UNESCO website.

Drop out by age and grade: School data

The available school information allowed an estimate of the drop out rates by age for grades 1-5 in 1997 and 1998. To make this calculation, the Legare method was modified to include each age and grade group as a separate mini-cohort. Otherwise, the calculations are as above. The calculations require repetition rates or the number of repeaters. Three estimations were made: constant repetition rates, repetition rising with age, and repetition falling with age (see Appendix Table C). Figure 7 shows the age and grade specific drop out rates for 1997 arranged by grade. The overall drop out rates for each grade – counting all the ages in each grade together – are shown in the panels along with the rates calculated above.

Figure 7. Estimated drop out rates using school data and three variations for repetition rate: constant repetition regardless of age (solid black line); lower repetition at higher ages (solid gray line); and higher repetition at higher ages (dotted line).



For grade 1, estimated drop out rates at ages 9-13 are negative, and similarly for grade 2 age 11, grade 3 age 7 and grade 4 age 8. Negative drop out rates mean that the mini-cohort grew: there were *more* pupils enrolled in 1998 at age *x+1* (including repeaters and those who were promoted), than there were at age *x* in 1997. If the ages of many pupils at lower grades were reported too low, particularly in the first grade, this is the pattern of numbers we would expect. Say a pupil who was actually 9 years old told teachers she was 7 when she entered first grade (or teachers reported her age as 7). Assume she was promoted, and that when she got to second grade in the next year, her real age, which would be 10, was reported. In the statistics, there would suddenly be an extra pupil age 10 in the second grade, while a 7 year old first grader would appear to have dropped out. With enough similar cases, one would observe, as we do, negative drop out rates for children who were 9 in grade 1, and exaggerated drop out rates for 7 year old first graders. This finding supports hypothesis 1 above.

A second finding from the figures is that in grades 3 and 4 drop out rates rise with age, regardless of the repetition pattern chosen. The differences are large: for example in third grade (with rising repetition rates) only 0.05 of the 7 year olds dropped out of school, compared to 60% of the 16 year olds. Moreover, the constant and falling repetition rates produce implausible negative drop out rates at ages 7-9. Only rising repetition – from 0.1 at younger ages, to 0.3 for older pupils in both grades – have overall positive drop out rates. This seems to indicate that within grades 3 and 4, like drop out rates, repetition rises with age (it might if, for example, higher order repetition leads to discouragement and drop out).

For grades 1 and 2 rising drop out rates are less obvious. At least one can say that drop out rises from age 11 onwards, but that the pattern at younger ages is unclear, due to age under-reporting.

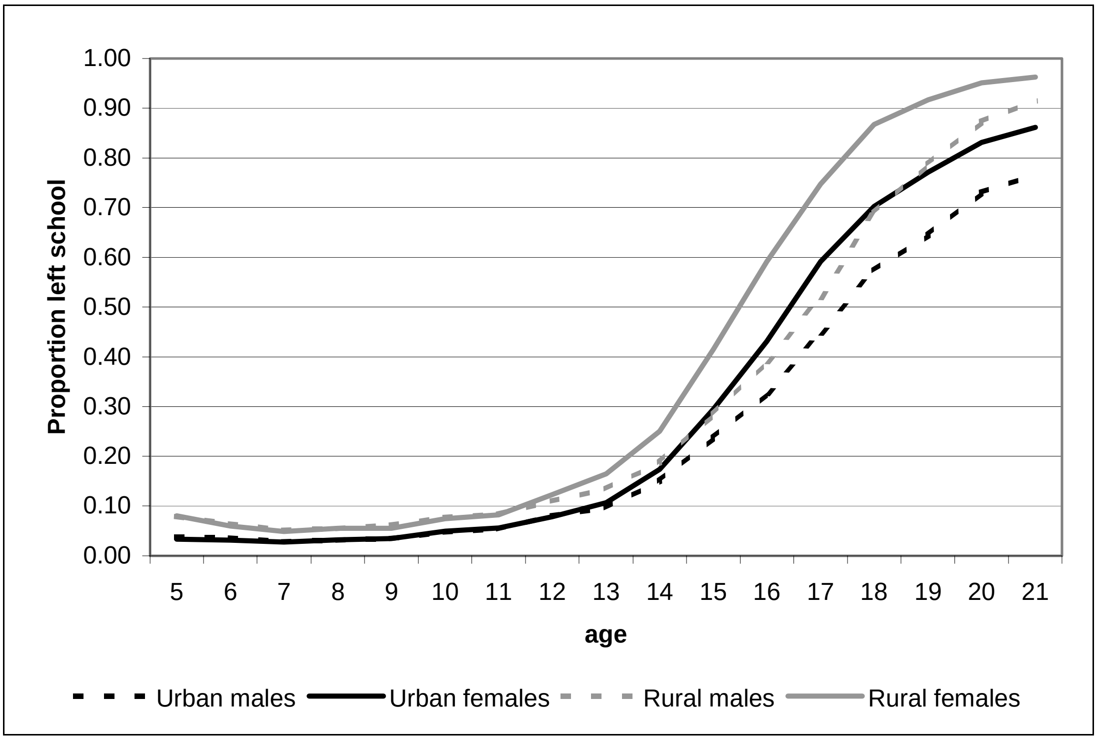
Drop out by age: Census data

Figure 3 above shows the proportion who left school and those who are enrolled using the census data. Together, these form the group of people who have had access to schooling. We can see that, of this group, the proportion who left school increases with age, as it should. Figure 8 shows the proportion, which has left school from ages 5-21 for urban and rural males and females. The proportion, which has left school (of those who entered) by age *x* is:

$$l_x = 1 - e_x / \Sigma s_x \qquad 6)$$

where e_x is the proportion of the age cohort enrolled in school at age x, and Σs_x is the total proportion of people who entered school at age x or before.

Figure 8. Proportion of children who have left school, of those who attended, ages 5-21, 1997. Calculations made with data from the Instituto Nacional de Estatística (1999).



The figure shows that for all four groups, the proportion which has left school is under 10% up to ages 11-13, depending on the group. It is clear that retention at young ages is high. During the teenage years, the proportion which has left school rises most for rural females and least for urban males. By age 21, only 4% of the rural women who ever attended school are still in school, compared to 23% of the urban men. By age 28, 95% or more of each of the four groups has left school. More than 40% of the adults ages 20-34 who are attending school are enrolled in primary. This means that older teenagers and adults enter, or return, to school.

It is clear that most school departure occurs in the teenage years and very little in the pre-teen years. The school retention implied by the census and by the school data appear to contradict each other. How can it be that more than 90% of those who have ever entered school are still in school by ages 11-13 (most of those in lower grades), when the enrollment data indicate that 13% to 20% are lost with each grade progression in the lower grades?

The explanation must lie in the heterogeneous drop out rates as discussed above. The older the pupil in each grade, the more likely he or she will drop out. If this is true, then it might be possible to have high retention rates at young ages, even though the *overall* drop out rates in each grade are comparatively high. Since the younger pupils in each grade are those who enter school early, and possibly, those with lower repetition rates, hypothesis 2 is:

H2: Young school entrants have lower drop out rates than older entrants.

Cohort Reconstuction with Age-Differentiated Entry and Drop Out

To test the hypothesis, we reconstruct school attendance in Mozambique in such a way that the results show drop out by grade and age, as well as overall school enrollment by age in 1997. A number of adaptations were made to the Legare method. First, to account for age-differentiated school entry, we treat each age-entry cohort as a separate group. Second, drop out and promotion are differentiated by age-of-entry. Third, historical rates of school promotion, repetition, and departure are used for the reconstruction.

Historical entry, repetition and departure

Because of Mozambique’s restless history over the past 20 years, school attendance has fluctuated considerably. In the first years after independence in 1975, before conflicts between the government and the opposition movement grew into a full-fledged civil war, apparent intake rates rose quickly. Unfortunately, as the war intensified and the opposition targeted schools in particular, intake dropped by 50%, to 63 in 1992. Since the signing of the Peace Agreement in 1992, apparent intake has risen again and was 113 in 2000.

School survival by grade fluctuated as well. High intake rates, but also very high drop out rates characterized the early period of independence. In 1982, for example, only 21% of those who entered school reached fourth grade, the lowest in Africa at that time (according to available data). Throughout the war, there was actually a gradual tendency for school survival to increase. In 1993, survival to fourth grade was 47%; by 1994 it was 58% and it has remained constant since then. Repetition by grade has been largely unchanged since 1981, fluctuating between 23% to 30% (depending on the grade), with a slight tendency to decline.

Putting variable school intake over time into the reconstruction is relatively easy; we simply shift cohorts up and down according to the relative apparent intake rate for that cohort (the most recent cohort is the base). Survival and repetition variation is very difficult, and would require simulation rather than a spreadsheet reconstruction. Luckily, school survival and repetition did not shift recently as much as intake. A majority of pupils who were in school in 1997 had entered since 1993.

Another problem is the entry rates by age. While the analysis above suggests that the age pattern of school entry indicated by the school data exaggerates the entry rates of young pupils at the expense of older ages, it does not indicate by how much. As a solution, the entry age pattern found with the census data is used (see Figure 5).

Reconstuction assumptions

There are, of course, a number of simplifying assumptions in the reconstruction. First, school survival and repetition are assumed constant over the historical period included in the reconstruction. For the years 1994-1997 this assumption is close to reality; in earlier years, survival was lower than in the reconstruction. This means that the reconstruction will tend to inflate enrollment at higher ages and higher grades.

Second, within each age-of-entry group, promotion, repetition, and drop out are constant regardless of how many times the student has repeated the grade. This is the same assumption as Legare and UNESCO use in their calculations of survival. In reality, multiple repetition probably acts as a discouragement, so drop out rises with the number of repetitions in a grade. One effect would be higher repetition rates for older pupils within each grade (as suggested above). Since the numbers for second and third order repetition are small in the calculations, this effect does not make a big difference to the outcome. Promotion might vary between those who are in a grade for the first time and repeaters, although it is hard to say in which direction. On the one hand, repetition gives slower students more time to acquire the necessary knowledge; on the other, the weaker students are those who repeat.

Further, it is assumed that school entry occurs in ages 5-25 and school enrollment up to age 34 is reconstructed. The pattern of school entry by age is constant, but the level is variable depending on the year of entry. Although the school data does not show any school entry beyond age 15, the high incidence of primary school enrollment at ages 20-34 suggests that there is some.

Reconstruction method

To include school entry at multiple ages, the spreadsheet for the synthetic cohort (see Appendix Table A) has to be rearranged to accommodate three rather than two dimensions, namely, age of entry, years since entry, and grade. We rearranged age of entry and age as a column, and years since entry in rows, with grade as a secondary category in rows, as shown in Appendix Table B. The first column shows the estimated school entry rates for 1997. The second column has those repeating grade 1, equal to the number of first graders in the previous age group in 1997 times the repetition rate. The third column has those in grade 2 for the first time, equal to the first graders in the previous age group times the promotion rate. And so it continues for all ages, grades, and orders of repetition. The calculations were made for grades 1-12 and for 16 years, which lobs off a small proportion of the enrollment at the highest grades, because with high repetition rates, it takes many students more than 16 years to complete the full school cycle. However, the numbers are very small: by year 16 only 1% of the original school entrants is still enrolled.

The synthetic cohort of Legare is prospective: higher order years (those who are in their second, third, etc., year of school) are years beyond the base year. In the historical reproduction, it is the other way around: those who are in their second, third, etc., year are pupils who entered *before* the base year. For example, with 1997 as the base year, those in year 2, rather than being an estimate of school enrollment in 1998, would be pupils who entered in 1996 and are in their second year of school. Those in year 3 would be pupils who entered in 1995, and so on. The reconstruction includes historical variation of school intake by multiplying the pupils in year *x* of the synthetic cohort with the ratio of school intake (1997-X+1):intake(1997). This change shifts school enrollment by age down (since pre-1997 intake was mostly lower than 1997) as compared to the synthetic cohort. It does not affect survival by grade and the proportion who have dropped out by age.

This reconstruction is used to test the effects of age-uniform and age-differentiated school experiences. In the uniform-rate calculation, promotion, repetition and drop out rates – equal to the overall, grade-specific rates of 1997 – were the same within each grade, regardless of age of entry. For age-differentiated school performance, separate sets of promotion, repetition, and drop out are prepared for each age-of-entry group. Two sets of variations were tested. In the one that is used, repetition is constant regardless of age of entry; drop out is differentiated; and promotion rates are the residual of one repetition rate-drop out rate. In another set, the promotion rates are held constant, and repetition is the residual of one promotion rate-drop out rate. The thought is that although students of all ages would have similar performances within a grade, repetition would act as a greater discouragement for older pupils. The second set of experiments does not reproduce the historical values of survival and enrollment nearly as well as the first.

Table 3. Overall 1997 promotion, repetition, and drop out rates, and four groups differentiated by age of entry. Source: Authors' calculations.

	Grade											
	1	2	3	4	5	6	7	8	9	10	11	12
All ages together												
Promotion rates	0.59	0.62	0.56	0.61	0.41	0.51	0.26	0.50	0.58	0.25	0.89	0.78
Repetition rates	0.31	0.28	0.29	0.24	0.24	0.33	0.35	0.33	0.31	0.40	0.09	0.22
Drop out rates	0.10	0.10	0.15	0.15	0.35	0.16	0.39	0.17	0.11	0.34	0.03	0.00
Entrants age 5-7												
Promotion rates	0.68	0.69	0.70	0.70	0.55	0.51	0.41	0.50	0.58	0.36	0.89	0.78
Repetition rates	0.31	0.28	0.29	0.24	0.24	0.33	0.35	0.33	0.31	0.40	0.09	0.22
Drop out rates	0.01	0.03	0.01	0.06	0.21	0.16	0.24	0.17	0.11	0.24	0.03	0.00
Entrants age 8-10												
Promotion rates	0.66	0.63	0.69	0.61	0.24	0.42	0.06	0.54	0.60	0.32	0.89	0.78
Repetition rates	0.31	0.28	0.29	0.24	0.24	0.33	0.35	0.33	0.31	0.40	0.09	0.22
Drop out rates	0.03	0.09	0.02	0.15	0.53	0.25	0.59	0.13	0.09	0.28	0.02	0.00
Entrants age 11-14												
Promotion rates	0.63	0.53	0.49	0.38	0.03	0.01	0.06	0.50	0.58	0.36	0.89	0.78
Repetition rates	0.31	0.28	0.29	0.24	0.24	0.33	0.35	0.33	0.31	0.40	0.09	0.22
Drop out rates	0.06	0.20	0.23	0.38	0.74	0.66	0.59	0.17	0.11	0.24	0.03	0.00
Entrants age 15-25												
Promotion rates	0.40	0.13	0.11	0.15	0.03	0.18	0.06	0.50	0.58	0.25	0.89	0.78
Repetition rates	0.31	0.28	0.29	0.24	0.24	0.33	0.35	0.33	0.31	0.40	0.09	0.22
Drop out rates	0.30	0.59	0.60	0.61	0.74	0.49	0.59	0.17	0.11	0.34	0.03	0.00

To find the differentiated drop out rates, the population was manually divided into age-of-entry groups and the drop out rates are manually tweaked to achieve a “good” fit of the reconstruction to the data. In other words, there was neither a computerized iteration procedure nor a formal measurement of the “good” fit. This led to four age-of-entry groups: those who enter school at ages 5-7; ages 8-10; ages 11-14, and ages 15-25. In reality, there is no doubt a continuum of school experience by age of entry, rather than discrete groups. Also, the actual drop out rates probably differ from those estimated. It should be noted, however, that any changes to drop out tend to ripple through the whole, enrolled population, so there is no room for terribly large errors. The results are shown in Table 3.

The reconstruction results are fitted to three empirical observations: 1) survivors by grade in 1997 – from school data; 2) the proportion who left school by age *x* – from the census data; and 3) overall age-specific school enrollment – from the census data. In the spreadsheet, survival by grade *x* is equal to the sum of all those enrolled in grade *x* divided by the sum of enrollment in grade 1. Age specific enrollment is equal to the sum of all enrollment at each age, regardless of age of entry, grade, and year. Finally, the proportion of those who have dropped out by age *x* is equal to one minus enrollment at age *x* divided by the sum of school entry by age *x* (see Eq. 6).

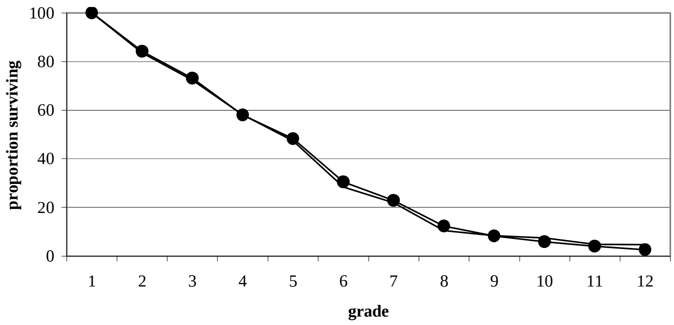
The results are shown in Figure 9 in three panels for 1) historical 1997 values (solid line), 2) historical reconstruction with uniform drop out rates (solid line with squares), and 3) reconstruction with drop out differentiated by age of entry (solid line with circles). In panel A for survival by grade, all three lines overlap. The uniform reconstruction rates are identical to the 1997 historical values, which are produced with uniform drop out rates (so they are identical for the reconstruction with historical and uniform rates). The differentiated reconstruction was able to reproduce survival almost exactly.

In panel B, the proportion who has left school, the uniform rate reconstruction leads to an immediate and fairly constant rise in the proportions who have left school, quite contrary to the 1997 values. The differentiated reconstruction does much better. It has the same sigmoidal shape as the historical values, although it rises at slightly younger ages – we were not able to remove this discrepancy with the four age-of-entry groups. Perhaps it would be possible with single year age-of-entry categories. In fact, shifting from two to three to four age-of-entry groups led, with each step, to a closer reproduction of the historical values. To go beyond the four groups was impractical, however, because there were strong diminishing returns to effort, and the manual fitting procedure became more complicated with each additional group. More importantly, it did not look like further disaggregation would lead to important new insights.

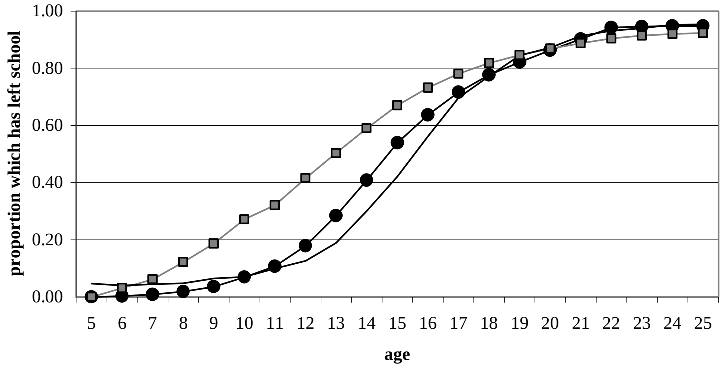
Panel C shows age-specific enrollment. The uniform rate reconstruction results in enrollment levels that are too low from ages 7-18, and too high at older ages. Moreover, the absolute number of students (found by multiplying each age-specific enrollment rate by the population of that age) is far too low with constant drop out. The differentiated rate reconstruction fits much better to the census data, and the number of pupils is correct. The actual number of primary and secondary school students, according to the 1997 census, was 2.009 million. The uniform rate reconstruction leads to only 1.644 million, while the differentiated reconstruction produces 2.016 million students.

Figure 9. Survival by grade (panel A), proportion who have left school by age *x* (panel B), and school enrollment by age (panel C) for 1997. Historical values (solid line), historical reconstruction with uniform drop out rates (solid line with squares), and reconstruction with drop out rates differentiated by age of entry (solid line with circles).

Panel A. Survival rates



Panel B. Proportion left school by age *x* of those who entered school.



Panel C. Age-specific enrollment rate.

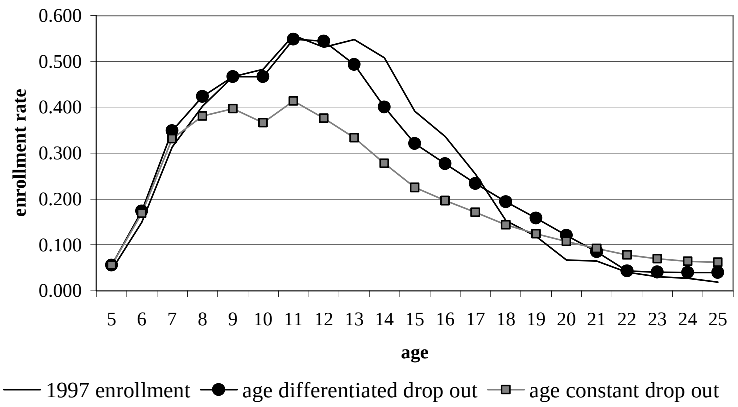


Table 4 shows survival rates to grade *x* and total grade expectancy for the overall historical rates of promotion, repetition, and drop out, and for the four age-of-entry groups using the differentiated rate reconstruction. The young entrants, ages 5-7, have very low drop out percentages in grades 1-4; in fact, we found that 86% of those who enroll reach grade 5, the last grade of the lower primary cycle. The school entrants ages 8-10 also do relatively well in primary school: 65% finish the first cycle. In the age-of-entry group 11-14, only 23% reach grade 5, and of the oldest entrants, only 0.3% (not shown in the table due to rounding). The expected grades completed are commensurate; 6.9 grades for the youngest entrants; 4.7 for the second group; 3.3 for the third; and 1.7 for the fourth. Interestingly, the 6.9 grades are about equal to the expected grades completed in Cidade de Maputo, where 85% of the entrants who enter before age 13 are ages 5-7.

Table 4. Survival by grade and grade expectancy in 1997 with overall historical rates, and estimated for young entrants (ages 5-7), entrants ages 8-10, ages 11-14, and ages 15-25.

Age of Entry	Grade expectancy	Survival to grade 1	2	3	4	5	6	7	8	9	10	11	12
All ages	4.4	100	86	74	58	47	26	20	9	7	6	4	4
Ages 5-7	6.9	100	99	95	94	86	63	48	32	25	22	16	16
Ages 8-10	4.7	100	96	84	81	65	21	14	3	3	3	2	2
Ages 11-14	3.3	100	91	66	45	23	1	0	0	0	0	0	0
Ages 15-25	1.7	100	57	10	2	0	0	0	0	0	0	0	0

Conclusions

School entry and school retention are important measures of a school system's success. The school system of Mozambique has long been lacking in both aspects, in part due to the havoc wrought by a 16-year civil war, and before that, a racially discriminating colonial system. Recently, there have been great improvements. Whereas apparent school intake in 1992, the year of the Peace Agreement, was only 60 (67 for boys, 53 for girls), by 2000, the numbers were 105 for females and 121 for males. The average for both sexes was 113.[10] School retention has remained constant over the post-war period. In 1994, those who entered school could expect to remain 5.9 years according to the 1994 promotion, repetition and drop out rates; in 1999, the number was hardly changed, 6.1 years.

One of the characteristics of the school system of Mozambique, as in many other sub-Saharan countries, is delayed school entry. Probably, during this period of rapid school expansion, there is more delayed entry than might be the case in a stable school system, as older pupils start school in regions that were previously unserviced. Delayed school entry has not received much attention in the literature despite its prevalence. This is unfortunate, because the results of this paper show that late school entry can have serious effects on school achievement.

The analysis is based on school intake, school retention by grade and by age, and expected years of schooling using two important data sources: the 1997 population census and annual data collected from schools. The combination of the two sources shows an apparent discrepancy with regards to entering and leaving school. The school data imply far higher entry at ages 6-9 than the census and lower entry for the older children. Whereas the census results indicate that school drop out in the pre-teen years is very low; the annual enrollment data from schools show that drop out in each grade is high, including those grades that are largely populated by pre-teen pupils.

[10] Data made available by the Ministry of Education, Maputo.

A further analysis of the data led to two hypotheses to explain these discrepancies:

H1: Pupil age reported in grade 1 and possibly 2 is often lower than the actual age.

H2: Young school entrants have lower drop out rates than older entrants.

In order to test the hypotheses, we furthered the synthetic cohort method proposed by Legare (1972) and used by UNESCO for the calculation of school survival by grade. The cohorts were separated not only by grade in year *x*, but also by age in grade. This simple change was used to test H1. To test H2, a historical reconstruction was made, rather than a period analysis. This included age-differentiated rates of school entry, repetition, promotion and drop out, and historical shifts in school entry. With this new method, 1997 school enrollment, survival and drop out rates were reconstructed with age-uniform repetition, drop out and promotion rates (within each grade) and with age-differentiated rates.

The examination of H1 reconstructed drop out rates by age, using data from schools for pupils by age and grades 1-5 in 1997 and 1998. The analysis shows that with the ages reported in grade 1, there are high drop out rates for ages 6-8, and implausible *negative* drop out rates for ages 9-13. This pattern would arise if many pupils in the first grade were reported to be younger than they actually are, and if, by grade 2, the correct age were reported. In grade 2, there would be a large influx of older pupils not reported from grade 1 (causing negative drop out rates), and there would be a significant loss of younger ones.

The historical reconstruction to test H2 shows that by differentiating drop out rates by age of entry, the low drop out rates in the pre-teen years observed by the census can be reproduced, while maintaining the observed survival by grade and school enrollment by age. According to the reconstruction, the school experience of young entrants differs substantially from that of older ones. While those who entered school at ages 5-7 could expect to complete 6.9 grades, according to the estimation, those who entered at ages 8-10 would complete only 4.7 grades; entrants ages 11-14 would complete 3.3 grades; and the oldest entrants a mere 1.7 grades.

We do not pretend that the drop out rates used in the reconstruction are an exact picture of reality. In particular, the more likely variation of drop out rates is a continuum by age, rather than a discrete difference between four groups. However, these results were achieved with many manual variations and it was found that there is not much room for maneuvering because each change ripples through the entire school population, in particular, changes at early grades. We believe that even this simplified reconstruction makes a strong case in support of the hypothesis that school departure is heterogeneous by age of school entry, and further that the heterogeneity is large.

It is plausible that early entry might lead to longer school enrollment. Some of the causes for differential drop out rates could be: higher motivation among parents who send their children to school as soon as possible; competing responsibilities at home and at work for older pupils; structural circumstances, such as a long distance to school, that make both early entry *and* continued enrollment difficult. While we did not reproduce the calculation for other countries in Africa, it is not unlikely that a similar heterogeneity exists elsewhere, as the causes proposed above are not unique to Mozambique.

In Mozambique, as school intake settles, there will not be as many older pupils from the catch-up effect of an expanding school system. As this happens, survival by grade should automatically increase. Even with this expected effect, a policy specifically aimed at younger school entrants could still be warranted. Also, policies to help older pupils stay in school could improve overall school survival. In some other countries, such as Botswana, even older pupils appear to remain in school. Perhaps something can be learned from policies there.

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Appendix Table A. Simple representation of the calculations made in the school survival method with no age differentiation.

Promotion rates		p1	p2	…	p12	
Repetition rates		r1	r2	…	r12	
Drop out rates		d1	d2	…	d12	Expected years enrolled by grade
Enrollment	year 1	E1,1 = 100				E1,1
	year 2	E1,2=E1,1*r1	E2,2=E1,1*p1			E1,2+E2,2
	year 3	E1,3=E1,2*r1	E2,3=E1,2*p1+E2,2*r2	…		
	…	…	…	…	E12,12=E11,11*P11	E1,12 … E12,12
	…	…	…	…	E12,13=E11,12*p11 +E12,12*r12	E1,13 + …+ E12,13
	…	…	…	…	…	…
	…	…	…	…	…	…
	year n	E1,n=E1,n-1*r1	E2,n=E1,n-1*p1+E2,n-1*r2	…	E12,n=E11,n-1*p11 +E12,N-1*R12	E1,n + …. E12,n
Total expected years enrolled						sum(E1,1 …E12,n)
Drop out	year 1	E1,1*d1		…		
	year 2	E1,2*d1	E2,2*d2	…		
	…	…	…	…	E12,12*d12	
	…	…	…	…	…	
	…	…	…	…	…	
	year n	E1,n*d1	E2,n*d2	…	E12,n*d12	
Survivors		S1=E1,1	S2=S1-sum(E2,2*d2…E2,n*d2)	…	S12=S11-sum(E12,12*d12…E12,n*d12)	
Expected grade completed						sum(S1…S12)

Appendix Table B. Synthetic cohort calculations with age differentiated entry (adapted from UNESCO method).

	Year	1	2	2	3	3	3		N	N	
	Grade	1	1	2	1	2	3	…	11	12	Expected years
Age	Entrants	Enrolled									enrolled by age
Age5	S5	E1,1,5=S5									E1,1,5
Age 6	S6	E1,1,6=S6	E1,2,6= E1,1,5*r1	E2,2,6= E1,1,5*p1							E1,1,6+ …. +E2,2,6
Age 7	S7	E1,1,7=S7	E1,2,7= E1,1,6*r1	E2,2,7= E1,1,6*p1	E1.3.7= E1,2,6*r1	E2,3,7=E1,1,6*p1 +E2,2,6*r2	E3,3,7= E2,2,6*p1				E1,1,7+ … +E3,3,7)
	…	…	E1,2,8= E1,1,7*r1	E2,2,8= E1,1,7*p1	E1,3,8= E1,2,7*r1	E2,3,8=E1,2,7*p1 +E2,2,7*r2	E3,3,8= E2,2,7*p1	…			E1,1,8+ … + E4,4,8
	…	…	…	…	E1,3,89= E1,2,8*r1	E2,3,9=E1,2,8*p1 +E2,2,8*r2	E3,3,9= E2,2,8*p1	…			…
	…	…	…	…	…	…	…	…			…
	…	…	…	…	…	…	…	…			…
Age25	S25	E1,1,25= S25	E1,2,25= E1,1,24*r1	E2,2,25= E1,1,24*p1	…	…	…	…			…
Age 26			E1,2,26= E1,1,25*r1	E2,2,26= E1,1,25*p1	E1,3,26= E1,2,25*r1	E2,3,26=E1,2,25*p1 +E2,2,25*r2	E3,3,26= E2,2,25*p1	…			…
Age 27					E1,3,27= E1,2,26*r1	E2,3,27=E1,2,26*p1 +E2,2,26*r2	E3,3,27= E2,2,26*p1	…			…
								…			…
Age6+ n									E11,n,5+n= E10,n-1,5+n-1*p10 +E11,n-1,5+n-1*r11	E12,n,5+n= E11,n-1,5+n-1*p10 +E12,n-1,5+n-1*r12	…
									…	…	…
Age25 +n									E11,n,25+n= E10,n-1,25+n-1*p10 +E11,n-1,25+n-1*r11	E12,n,25+n= E11,n-1,25+n-1*p11 +E12,n-1,25+n-1*r12	E1,n,25+n + …+E12,n,25+n
Total expected years Enrolled											Sum(E1,1,5 … E12,n,25+n)

Appendix Table C: Repetition rates.

Constant repetition

Grade	6-	7	8	9	10	11	12	13	14	15	16	17	18+	Overall
grade 1	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27				0.2700
grade 2	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.2600
grade 3		0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.2600
grade 4			0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.2200
grade 5				0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2000

Falling repetition by age

Grade	6-	7	8	9	10	11	12	13	14	15	16	17	18+	Overall
grade 1	0.40	0.33	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20				0.2679
grade 2	0.60	0.50	0.40	0.25	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.2669
grade 3		0.50	0.50	0.40	0.30	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.2578
grade 4			0.50	0.40	0.30	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.2218
grade 5				0.40	0.30	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.2065

Rising repetition by age

Grade	6-	7	8	9	10	11	12	13	14	15	16	17	18+	Overall
grade 1	0.10	0.20	0.30	0.35	0.40	0.40	0.40	0.40	0.40	0.40				0.2669
grade 2	0.10	0.10	0.20	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.2687
grade 3		0.10	0.10	0.20	0.20	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.2587
grade 4			0.10	0.10	0.10	0.20	0.20	0.25	0.30	0.30	0.30	0.30	0.30	0.2172
grade 5				0.10	0.10	0.10	0.20	0.20	0.20	0.30	0.30	0.30	0.30	0.2031

SKILLED LABOR IN MOZAMBIQUE, 1960-2020

Maimuna A. Ibraimo

Introduction

Mozambique is a country that has risen from the catastrophe of an extended war, which ended in 1992. Since the democratic elections in 1994, economic growth has been high, averaging 8% annually until natural disasters imposed economic setbacks in 2000. One of the main bottlenecks that may impede further rapid growth and rising labor earnings is the negative impact of the HIV/AIDS pandemic on production and wages through declines in the availability of skilled labor. For this reason, it is very important to examine the quantitative link between HIV/AIDS, the market for skilled labor, and overall economic growth. The purpose of this paper is to examine this relationship using an economic-demographic model developed specifically to simulate conditions in Mozambique (Wils et al. 2001).

The 1997 population census estimated that only 12,083 economically active persons had completed a bachelor degree of education or more. This corresponds to only 0.07% of the population. Initial estimates by the Ministry of Health indicate that 16% of adults aged 15-49 are infected by HIV/AIDS, and that this rate will stabilize at 17%. Projections by the International Institute for Applied Systems Analysis (Wils et al. 2001) include a more pessimistic scenario, in which the incidence rate rises to 35%. Even in the optimistic case, HIV will infect 1.8 million people from 1998 to 2010; this corresponds to an annual 7.1% spread of the disease. Over the same period, 1.7 million people will die from the pandemic. The death rate by HIV/AIDS is at 6.7% per year. The consequence of this negative impact is that population growth will be reduced from the estimated rate of 2.3% per year in the absence of AIDS, to 1.4% with AIDS. In addition, life expectancy will decline from 50.3 years to only 35.9 years.

The skilled labor force will also be hard hit. This will have negative implications on domestic production. On the one hand, the lack of skilled labor keeps away potential investors; on the other, a lack of managerial expertise can hinder efficient governing of the country and productive use of existing investments. In addition, the real wage will be affected by HIV/AIDS: When economic growth is low, the demand for skilled labor grows more slowly. Since the supply of labor also grows more slowly due to HIV/AIDS, the net effect on the wage is an empirical issue, which is addressed below.

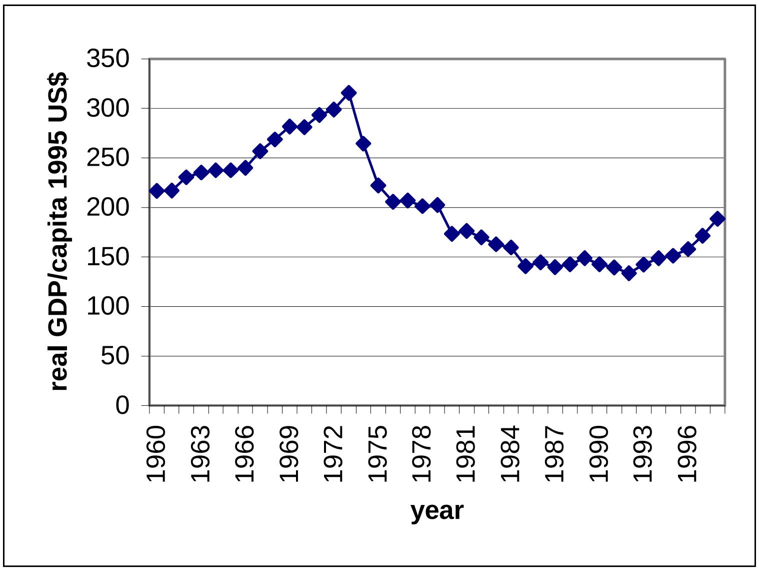
Another issue that we propose to analyze in this paper is the relation between the loss of skilled labor over time and the loss of overall population. Our hypothesis is that skilled labor will be less affected by HIV/AIDS, because men dominate the skilled labor force, while women are more vulnerable to HIV infection. Also, most of the skilled workers reside in the southern region, where prevalence rates are lower.[11] Other implicit assumptions are: 1) skilled labor has more access to information, as compared to the overall population; 2) skilled labor is more easily influenced by prevention campaigns and is therefore more likely to use preventative measures; and 3) if medicines were available to delay deaths by AIDS, skilled labor would be more able to purchase them and survive longer.

The paper begins with a background to the Mozambican situation. Next we analyze the size of the skilled labor, its composition, and its relationship to the country's economic performance. We also review the characteristic of skilled labor and its employment. The next section reviews the prevailing situation in higher education, followed by an examination of the determinants of the real wage for skilled labor. Finally, we define our projection scenarios and present the quantitative findings.

Skilled Labor and the Growth of the Economy

Although Mozambique was one of the world's poorest countries in 1990, it ranked among those countries with a medium level of development prior to independence (in 1975). In 1970, GDP was over US$ 300 per capita (in 1995 prices). According to the World Penn Tables (Heston and Summers 2002), in terms of real per capita income, the country ranked 80th out of 133 countries in 1970. The trend for GDP per capita was upward – there was a 50% increase between 1960 and the peak year in 1973 (see Figure 1).

Figure 1. GDP per capita from 1960 to 1997 in Mozambique. Sources: 1960-92 real GDP from PENN tables (Heston and Summers 2002); 1992-98 real GDP from World Bank Africa Tables (World Bank 2002).



[11] In the southern region the adult prevalence rate is estimated at 11% in 1999 and is expected to be stable at 14.3% after 2005. In the central region, the rate ranges from 20.3% to 21.4%; in the north it ranges from 13.0% to 14.4% for the same period of time (MISAU et al. 2000).

Even in this period, the proportion of the population with higher education was low. In 1960, there were 2,476 people or 0.03% of the population with tertiary degrees. Most were Europeans, particularly Portuguese. In that year 94% of the highly educated people in Mozambique were Whites; 4.5% were Asians and other non-African ethnic groups. Only 1.5%, or a little more than 39, of those with a bachelor degree or other university education were Africans (estimations are based on Repartição de Estatística 1969). At the time of the 1970 census, the number of people who had a bachelor or university degree was 4,959, or 0.05% of the total population (estimations are based on Repartição de Estatística 1973) (see Table 1).

Table 1. Skilled personnel from 1960-1997, total numbers and as a percentage of the population. Sources: Instituto Nacional de Estatística (1970, 1997b); CNP (1980).

	Bachelor and university degrees	High school level and above	Population size (thousands)	Proportion of skilled population
1960	2,476	25,296	7,461	0.030
1970	4,959	42,032	9,398	0.050
1980	3,265	34,962	12,100	0.027
1997	12,083	61,411	16,099	0.070

With national independence in 1975, Mozambique lost a large part of this small group of educated people. Virtually all of the Portuguese left the country in a hurry, destroying large portions of fixed capital as they went. During the final two years of colonial rule, GDP per capita plummeted from over US$ 300 (1995 constant dollars) to just over US$ 200 in 1975.

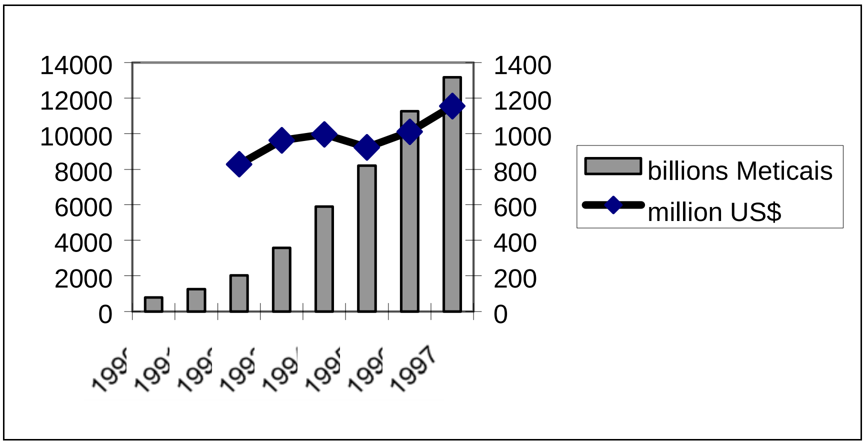
Even though the government undertook huge efforts to expand education in a short period of time, it was not possible to make up for the loss of skilled labor quickly. Moreover, the government concentrated its efforts on primary education. To some extent the lack of skills was compensated by external technical assistance. Unfortunately, from the available data it is not possible to discern the size of the skilled labor force filled by external assistance for 1980. However, it can be said that by then the external technical assistance, mainly coming from the ex-socialist block, including Cuba and the former Soviet Union, covered the needs in education, health, agriculture, and economic planning. By 1980, the census recorded only 3,265 skilled persons (both nationals and expatriates), 0.03% of the total population.

During this period, and in particular during the brutal civil war, real GDP per capita continued to decline slowly. This trend continued in spite of a move away from socialism in 1987, with the structural adjustment program worked out in conjunction with the World Bank and the IMF. By 1992, the last year of the civil war, real GDP per capita was only 30%-40% of the 1973 level (depending on the calculations used).

After the signing of the Peace Agreement in 1992 and in particular after elections in 1994, we observe a very encouraging picture of economic recovery. While in 1992, real GDP per capita was estimated to be only US$ 133 (1995 constant dollars), by 1998 it had reached US$ 188, an increase of over 40%. In 1997 alone, real GDP per capita increased by 11% compared to the previous year (World Bank 2002).

High levels of economic growth, largely due to post-war reconstruction, were evident in most sectors of the economy, in particular agriculture, services, and construction (industry did not pick up immediately). The 1993 GDP growth of 8.7% was centered in agriculture, transport and communications, and services. Figure 2 shows the percentage of production variation by economic sector between 1992 and 1998. From 1992 to 1993, the service sector reached a change of production of 35%, while agriculture and livestock had a change of 21%. Certainly population resettlement and the free circulation of goods and services allowed this change. Yet high growth continued in the following years, exemplified by percentage changes in the trade and service sectors (26.2%) and in transportation and communications (24.1%) from 1996 to 1997. Between 1997 and 1998 growth in transport and trade abated to 3.2% and 10.1%, respectively; the major growing sector was construction (38%).

Figure 2. Investment 1990-97 in billions of Meticais and in millions of US dollars.



Increased investment, both private and public (see Figure 2) played an important role in this growth. Investments amounted to US$ 827 million in 1992 and US$ 1,156 million in 1997. This indicates an investment/GDP ratio (after excluding public investment) of 19% in 1996 and 23.3% in 1998 (Instituto Nacional de Estatística 2000). It is expected that in the future, these new investments will lead to an even higher rate of not only exports, but also domestic consumption of marketed goods and services.

The present growth trend is probably also stimulated by increases in education. At the time of the 1997 population census, there were 12,083 persons in skilled labor (defined here as persons with tertiary education). This equals 0.07% of the total population, more than double the 1980 proportion, but still a very small number. Of the total skilled labor in 1997, 8.2%, or 990 persons, were expatriates, and the majority, 90.6% or 11,632 persons, were nationals.[12]

Characteristics of the skilled labor force in 1997

Most of the skilled labor (defined here as workers with tertiary education) is settled in the major urban areas. Only 15% is located in rural areas (see Table 2). As expected, almost all of the skilled persons work; the unemployment rate is very low, 2.7%. Among nationals it is 2.8%, while only 1.1% of the expatriates, who very often arrive after having the job contract guaranteed, are unemployed.

[12] These data and others concerning the skilled labor force are made available through specially prepared census tabulations at the Instituto Nacional de Estatística.

Table 2. Skilled labor force by nationality according to sex, 1997. Source: Special tabulations of the 1997 population census by the Instituto Nacional de Estatística (1999). Special thanks to Tomas Bernardo.

	Urban	Rural	Total
Foreign	–	–	990
National	–	–	11,092
Total	11,632	451	12,083

A serious problem with the skilled labor force is that it is largely composed of very young people whose work experience needs to be enhanced. The majority of the skilled labor, 78%, is younger than 40 years old, and 22% are aged 40 and above. This is unavoidable in an expanding education system (since most graduates are young people) but nonetheless it poses grave problems to an economy in need of experienced managers and executives.

Another aspect of the skilled labor force is that it is largely composed of men. The ratio of skilled men to women is 3.7. However, this ratio is somewhat lower in the younger age groups. For example, in the age group 20-24 the ratio is only 2.5, and 3.3 in the age group 25-29. For older cohorts, the male to female ratio is much higher, for example, 4.7 in the age group 50-54. This means that in recent decades, women have had a slightly more equal chance of receiving higher education and becoming part of the skilled labor force (see Table 3).

Table 3. Employed skilled labor by age and sex, Mozambique, 1997. Source: Special tabulations of the 1997 population census by the Instituto Nacional de Estatística (1999).

Age groups	Male:Female ratio
All ages 15+	3.7
15-19	1.6
20-24	2.5
25-29	3.3
30-34	4.0
35-39	4.1
40-44	3.9
45-49	4.7
50-54	4.6
55-59	6.9
60 and above	5.6

Sectors of skilled labor employment, nationals and expatriates

Employment patterns for skilled labor contrast deeply if we consider the colonial and the post-independence period. In 1970, for instance, only 154 (3%) out of 4,959 skilled persons were employed in public and private management activities. The majority was employed in technical activities: 1563 were in the agriculture sector and 2,276 were professionals in the scientific, technical and liberal activities.

As the country's political environment changed and planning activities became more complex, employment in managerial activities grew heavily at the expense of the technical ones. Table 4 shows the sector of employment for Mozambican and expatriate skilled labor in

1997. Almost half of the Mozambican skilled labor force is employed by the government sector, mostly in public management. One-fourth is in private enterprises and one-tenth is self-employed. This means that the government in Mozambique, as in many other poor developing countries, is a major attraction for skilled labor. From these data, it is not possible to say to what extent the government competes with the private sector for skilled labor and exacerbates the skilled labor bottleneck, or whether the private sector is so small that it cannot absorb more skilled labor, and hence these people seek jobs with the government.

The expatriate labor, on the other hand, is largely concentrated in private enterprises or international organizations, namely, 53% in 1997. The reason is that international agencies (United Nations, NGOs and embassies) employ many expatriates, and probably the foreign investors in Mozambique employ people of the same national origin as the firm. Skilled foreigners hold almost one-fifth of the skilled jobs in private enterprises and comprise one-third of the skilled owners of enterprises.

A second major sector of expatriate employment is the government sector (19%) where these people are part of the technical assistance staff. Non-nationals account for 4% of the government employees (see Table 4). This is lower than the percentage in neighboring Botswana, where it is 7% (Kibuuka 1998). The fact that there is a relatively low percentage could be due to a low vacancy rate for government posts (i.e., no need for foreigners), or because wages in government are too low to attract foreigners, or because foreigners are hired as consultants or by international organizations.

Table 4. Skilled labor by occupation according to nationality, Mozambique, 1997. Source: Special tabulations of the 1997 population census by the Instituto Nacional de Estatística (1999).

Occupational category	Total	Mozambican	Expatriates
Mozambique	100.00	100.00	100.00
Government sector	49.78	52.57	18.71
Private enterprise	26.59	24.20	53.22
Public enterprise	7.36	7.68	3.77
Cooperative enterprise	0.74	0.52	3.16
Self employed	10.74	10.72	11.06
Household help	1.74	1.74	1.70
Cooperative employee	0.11	0.08	0.36
Owner/entrepreneur	1.34	1.02	4.86
Unknown	1.60	1.46	3.16

Cost of expatriates in the labor force

Despite the relatively low proportion of foreigners among the skilled labor force, high expenditures for expatriates are a significant drain on the public investment budget. Technical assistance (mostly salaries for foreign experts) forms a significant part of the foreign aid that Mozambique has received.

Between 1996 and 1997, Mozambique dedicated 12% to 14% of the public investment budget to studies, consultants and projects (MPF 1996). For the period of 1998-2000, it is expected that the annual average expenditure on technical assistance (including salaries and expenditures on goods and services by external consultants) will be around 6.5% of the overall investment budget (MPF 1998).

Technical assistance between 1991 and 1995 made up about one-fourth of the total assistance. Between 1991 and 1994 technical assistance fluctuated around US$ 200-250 million per year. It then declined to only slightly more than US$ 100 million in 1995 (see Table 5).

Table 5. External assistance disbursement by type (in thousands of US$).

Type of assistance	1991	1992	1993	1994	1995 (planned)
Free-standing technical cooperation	157,828	152,285	141,006	196,792	89,094
Investment related technical cooperation	85,561	90,758	46,270	70,922	27,423
Total technical assistance	243,389	243,043	187,276	267,714	116,517
Investment project assistance	198,915	189,120	235,145	241,106	137,738
Program/budgetary aid or balance of payment support	234,954	216,402	209,822	254,116	104,755
Food aid	110,729	229,284	155,465	114,016	37,363
Emergency and relief assistance	105,486	98,546	86,919	171,177	24,912
Grand total	893,473	9,763,395	874,627	1,048,129	421,285
Technical assistance as part of total	0.27	0.25	0.21	0.26	0.28

To put this into perspective, the total planned education budget in 1998 was US$ 112 million dollars. As described in Watt and Ibraimo (1999), this education budget will not be enough to help Mozambique out of its present poor education predicament. That study suggests that at least 5% of GDP would be necessary to truly improve the state of education (this would amount to US$ 160 million in 1998). What these numbers suggest is that the lack of skilled labor necessitates the expensive employment of foreigners, and that this expense competes with the expansion of the education system that would be necessary in order to raise the proportion of skilled labor. In other words, Mozambique is caught in a catch-22 situation, where on the one hand the government needs to employ skilled foreigners for the management of the country, but on the other hand, the funds used to pay them reduce the amount available for education. This brings us to the next subject, namely, the education of the skilled labor force.

Higher Education: The Formation of the Skilled Labor Force

The education pyramid

In this section, we review the overall education level of the population and specifically the enrollment in higher education. The low number of national skilled people in Mozambique is an expression of the overall low level of education. For example, in 1997, 60.5% of the total population aged 15 and above were illiterate (Instituto Nacional de Estatística 1997b). Of the total population aged 15 years and above in 1997, only 13% had completed the first level of primary education; 5.6% had completed two levels of primary education; and 0.80% had completed secondary education. An extremely low proportion, 0.14%, had a university degree (both bachelor and licentiate).

In general, there is a very flat education pyramid. At the bottom there is a large number of children attending primary school. The next level, secondary education, is much smaller; the third level, tertiary, is smaller still, as shown in Table 6. The primary level (EP1 and EP2) has 73.3% of all students, while 19.8% are in secondary school (ESG1 and ESG2), followed by 4.3% who attend higher levels of technical and teaching colleges. Only 1.3% of the students attend university. The pyramid is considerably flatter outside Maputo City and Province. Also, Maputo City and Province have a significantly higher proportion of students in the population than the other provinces.

Table 6. Gross and net enrollments by educational cycle, Mozambique, 1997. Sources: Instituto Nacional de Estatística (1999); MINED (1997).

	Gross enrollment rate	Net enrollment rate
1st cycle of primary school-EP1	81.09	42.29
2nd cycle of primary school-EP2	20.73	2.35
1st cycle of secondary school-ESG1	5.25	1.01
2nd cycle of secondary school-ESG2	1.80	
Medium level of technical education-ETM	0.65	
University	0.40	

It could be said that this educational pyramid reflects the young population structure of the country: 44.4% of the total population is less than 15 years old. To a certain extent, this is true. However, if we look at the enrollment rates by age, we see that there is a significant drop-off in enrollment by age (see Wils and Gaspar in this volume).

In 1997, the education statistics (MINED 1997) indicate that the country's population achieved a gross enrollment rate of 81.1% at the first cycle of primary education (EP1). Beyond this level, gross enrollment rates decline. In the second cycle (EP2), the gross enrollment rate is one-fourth of the EP1, 20.7%. At the first cycle of secondary education, ESG1, the gross enrollment rate is only 5.3%. For the overall post-secondary vocational (technical and teaching) education, it was 2.4%; of this, 1.8% is for general education and 0.65% is for technical and professional education. According to the same data, the net enrollment rate[13] at the first cycle of primary education reaches less than a quarter of the respective population, 17.4%. It was not possible to calculate the net enrollment rate for higher levels.

This is a very significant contrast to industrialized countries. In 1994, for instance, Canada had 100% of its children enrolled in primary school; the net enrollment in secondary school (full-time students) reached 94%; and 40% of the population between 18 and 21 years old was enrolled in school (UNESCO 2002).

While it is not possible to find transition rates per grade, the declining enrollment rates indicate that transition rates from one grade to the next are low. This contrasts to the fairly high transition rates from one level of school to another. Of the graduates from EP1 in 1996,

[13] The net enrollment rate indicates how many children *from the appropriate age group* are enrolled as compared to the total number of children who should be enrolled in a certain class given their age. For the gross enrollment rate, the denominator of the ratio is the same as above, but the numerator reflects the total number enrolled, irrespective of age.

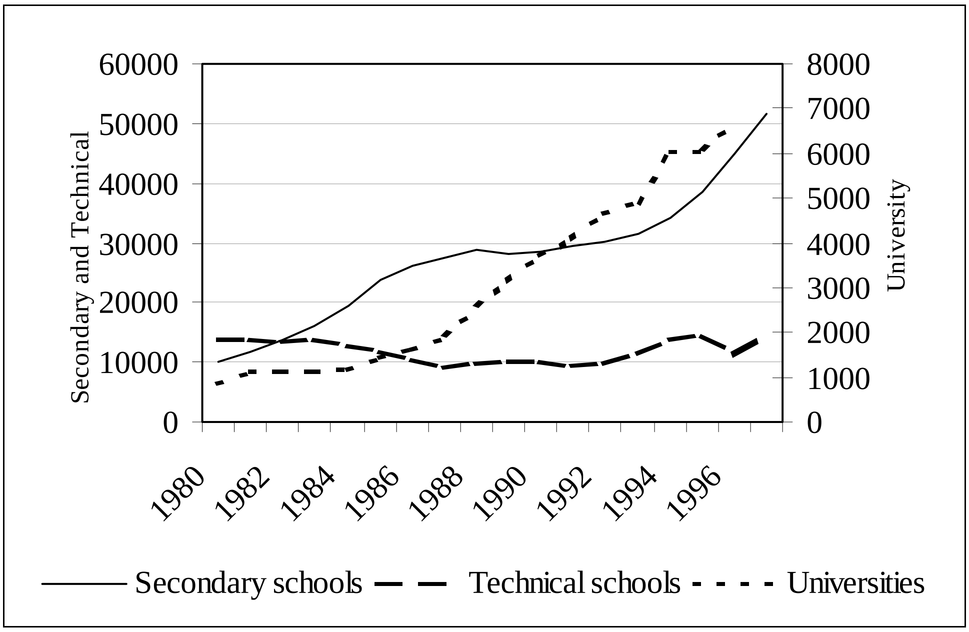
78% enrolled in EP2 in 1997. From EP2 to ESG1, this rate was 63.9%. Transition from ESG1 to ESG2 increases to 79.3%.

A more serious problem than low transition rates from one grade to the next appears to be the high repetition rates and the low graduation rates. Repetition rates for school are around 30% nationally (see UNESCO 2002). The graduation rates from ESG2, for example, are only 12.2%. The statistics for the largest university in the country, the University of Eduardo Mondlane in Maputo City, show that in the 1990/91 school year, 813 new students registered, but five years later, only 5 had graduated (Instituto Nacional de Estatística 1999).

Trends in enrollment of higher education

Enrollment and graduation at higher levels of education is increasing, as shown by Figure 3. The number of students in secondary schools and universities has increased by a factor of six or seven since 1980. Although secondary school enrollment stagnated during the civil war, university enrollment continued to increase. This is probably related to the fact that there was an accumulation of people who completed secondary education, but they could not find a place in the (until recently) only university in the country, the University of Eduardo Mondlane.

Figure 3. Enrollment in secondary and technical schools and in universities, 1980-1997. Source: Instituto Nacional de Estatística (1997a).



The graduation rate of these students is unfortunately low. In 1997, for example, only 266 students graduated from the University of Eduardo Mondlane according to the Ministry of Education, although the majority of the over 6,000 university students is registered there.[14]

The average growth rate of secondary enrollment between 1980 and 1997 was 10% annually; that of tertiary education was slightly higher, namely 13%. As these people leave school with higher skills, they contribute to a modest growth rate of the skilled labor force.

Geographical distribution of students and their origin

Schooling is concentrated in Maputo City, as shown in Table 7. While they only have 11% of the population, Maputo City and Province are home to more than a quarter of the student body. At all levels of schooling, except alphabetization, Maputo City and Province have more than their "population" share of the students.

Table 7. Level of education by place of residence, Mozambique, 1997 (in percentage). Distribution of students in school and by level of education for non-Maputo provinces and Maputo City/Province. Source: Special tabulations of 1997 population census by the Instituto Nacional de Estatística (1999). Special thanks to Manuel da Costa Gaspar and Tomas Bernardo.

	Total	Outside Maputo	Maputo City/Prov
Population	100.0	88.7	11.3
Pupils in school	100.0	73.7	26.3
Level of education			
Alphabetization	1.0	1.0	0.0
1st cycle of primary school-EP1	47.3	40.7	6.0
2nd cycle of primary school-EP2	26.0	18.6	7.1
1st cycle of secondary school-ESG1	15.9	10.3	5.4
2nd cycle of secondary school-ESG2	3.9	2.4	1.4
Lower technical school	0.4	0.3	0.1
Basic technical school	2.2	1.5	0.7
Middle technical school	1.2	0.7	0.4
Teacher formation	0.5	0.4	0.1
Tertiary	1.3	0.8	0.5

Secondary schools and especially institutions of higher education tend to be concentrated in urban areas, particularly in Maputo City,[15] far from the majority of the rural population, and most of the students attending universities are born in these cities. This means that students born in rural areas far away from the center of education are particularly disadvantaged and do not attend higher forms of education. According to the census data, 4,185 (64.2%) out of 6,523 university level students are living in Maputo City, the country's

[14] Here we should be very careful because many students finish a bachelor degree or complete the overall licentiate degree curricula without formally completing the course. In this case, the student is not considered to have graduated.

[15] In the near future we can expect a small change in the concentration of the university students in Maputo, as new university branches are being opened in other provinces of the country.

capital where the education infrastructure for these educational levels is concentrated. The capital city receives more than half of the students born in all Mozambican provinces (see Table 8). The remaining are concentrated in Maputo Province, 669; Sofala, 574; Nampula, 310; and Zambézia, 234. Moreover, a disproportionate number of the students are actually born in Maputo City. While only around 5% of the overall 1997 population was born in Maputo City, one-third of the students in secondary school or higher was born there. This means that children born in other provinces have less of a chance to attend university than those who are born in Maputo City.

Table 8. Students at tertiary levels of education by province of residence in 1996 and place of birth.

Province of residence in 1997 ⇒ Province of birth ⇓	Total	Niassa	Cabo Delgado	Nampula	Zambezia	Tete	Manica	Sofala	Inhambane	Gaza	Maputo province	Maputo city	unknown
Total	6,523	34	51	310	234	88	97	574	89	134	699	4,185	28
Niassa	157	23	1	16	5	1	3	11	4	2	8	83	-
Cabo delgado	192	2	32	21	2	1	-	6	-	-	13	110	5
Nampula	481	3	3	182	5	2	2	18	1	3	27	230	5
Zambezia	614	2	7	37	185	8	6	55	1	1	47	262	3
Tete	331	1	-	6	6	60	10	62	1	1	11	173	-
Manica	217	-	1	2	7	1	58	43	1	-	6	96	2
Sofala	563	-	2	5	3	4	9	272	1	4	21	242	-
Inhambane	717	-	-	7	4	5	4	43	57	24	63	510	-
Gaza	589	1	-	8	-	1	1	15	8	85	61	407	2
Maputo province	446	1	-	6	2	-	-	9	2	4	255	167	-
Maputo city	2,114	-	3	13	10	5	3	36	13	10	182	1,838	1
Unknown	102	1	2	7	5	-	1	4	-	-	5	67	10

Wage for Skilled Labor

Wage data are scarce, particularly, the wage data for the private sector in Mozambique. The existing sample on wages carried out by the Instituto Nacional de Estatística (1999) could serve as an approximate figure. However, while the survey tries to include both the private and public sector, it has the shortcoming of considering only those enterprises with 50 or more workers.

Nevertheless, from the official legislative publications and findings of other studies it is possible to discern that nationals and expatriates have different wage structures. Because the pay standards in international organizations and enterprises are much higher than in the public sector, the wages for the majority of the skilled labor tend to be lower, as long as they are mostly employed in the public sector. The lack of financial revenues mostly justifies the lower wages in the public sector.

Estimates from the wage survey indicate that from 1991 to 1997 average real wages (at 1991 prices) for skilled labor employed in the public sector decreased from 1,525,000 Meticais per month to only 753,000 Meticais (see Table 9). While prices increased by approximately 7.8 times from the 1991 level (the rate of the national currency devaluation as compared to the US dollar), wages rose by only 3.8 times their 1991 levels, meaning that the real wage in 1997 was only 0.49 that of 1991. This trend mirrors that of many other sub-Saharan countries at least in the 1980s (Jamal and Weeks 1993; International Labor Organization 1997). The unskilled labor wage rose by a factor of 6, which means the decline in real wages was less than that of skilled labor.

Table 9. Monthly wages by pay categories in Meticais per month, 1991 and 1997 in 1991 prices (CPI 1991/1997:779.13% and Deflator 1991/1997:7.76). Source: Estimates based on *Boletim da república*, Serie I, N46 (1991); *Boletim da república*, Serie I, N26 (1996).

Pay Category	1991 x1000	Nominal 1997 x1000	Real 1997 in 1991 prices	Ratio real 1997:1991
Licentiate degree	1,619	6,216	801	0.49
Bachelor degree	1,430	5,484	706	0.49
High school degree	1,264	4,844	624	0.49
International organizations (World Bank)		12,500		

For nationals working in the private sector the wage rate is unknown, but by 1995 to 1996 this sector was small and being restored after a long period of state ownership of most enterprises. Therefore, the average wage rate would not differ widely from the public sector. Additionally, the evaluation of the INE data on the above-mentioned enterprises gave a similar result for the average, medium and university wages for both the private and public sectors.

Given the structure for the public and a large part of the private sectors, it appears that the wage differential between Mozambique and its wealthy neighboring countries (South Africa and Swaziland) and the international organizations is very much to the disadvantage of Mozambique. Therefore, national wages negatively affected the migration of the skilled labor to the national economy, with the exception of the international organizations and businesses, both being a small proportion of the overall labor market for 1997.

The Future of the Wage Rate and Skilled Labor

The growth rate of the Mozambican economy over the past five years has been impressive, and this larger economy is expected to demand more and more skilled labor. In countries with high growth rates, such as Botswana, the increase in the national skilled labor force, through graduation from schools and universities and higher labor force participation rates, has not been able to keep up. There are high vacancy rates in the government for high skilled level posts and a high percentage of expatriates in these posts (Kibuuka 1998). Although the data for vacancies are not available for Mozambique, we do observe that, at least in the public sector, there is still room for the employment of skilled labor. In Botswana, the shortage of skilled labor will be made worse in the coming years by deaths from AIDS, which affects the skilled as well as the unskilled. Likewise, as the AIDS epidemic spreads into Mozambique, it is expected that there will be attrition among skilled labor from AIDS deaths. We now turn to an analysis of the impact of HIV/AIDS on the skilled labor force.

The Skilled Labor Model

The skilled labor model in the integrated model of population, development, and the environment

The skilled labor model was built as a component of an integrated model on population and development (Wils et al. 2001). The model considers the impact of AIDS in population growth, education, skilled labor and the economy. Environmental issues also enter into the model as factors affecting the economy.

The model starts with a healthy population by age, sex and area of residence, for 1997. Part of the population is contaminated by the HIV virus. How quickly new cases appear depends on the prevalence and incidence rates, and the relationship between these two rates. The most basic dynamic is that the more people are infected, the more the disease spreads to the healthy people, so in turn, the more are infected. People are susceptible to contamination depending on behavior, the practice of safe sex, and the introduction of medicines controlling HIV propagation. HIV infection causes AIDS and people die.

From the age of 5, people start to enroll in the education system. The number of people who complete primary education is determined by the dropout and repetition rates. The existing number of teachers will be augmented by the number of people leaving the teacher training program, and by part of the labor force with other educational careers. There is a shortage of teachers. Teacher losses are determined by retirement and by precocious deaths. The student-teacher ratio is one determinant of the efficiency of the education system. The lower the student-teacher ratio, the higher the primary education graduation rate in the model.

People aged 15 to 64 constitute the potential labor force. The population census data permit the identification of individuals who are available for production, that is, the economically-active population. This population includes individuals who never went to school, those who left school to work, the old stock of labor and the in-migrating population. Losses in this group are determined by deaths either by AIDS or by other causes. At the same time, the availability of labor is shaped by deductions of time needed to take care of AIDS patients. The size of the labor force is presented by area of residence, age, education and sex. The size of the population in urban and rural areas is additionally determined by education, where we assume that people who complete primary school migrate to the urban areas.[16]

GDP depends upon the production sector in the model. For the urban economy a Cobb-Douglas production function is considered, and refers to the modern sector of industry and services. Production is a function of the productivity factor (which rises over time at 3% per year), capital, and labor. Changes in capital stock are determined by the rate of domestic investment as a proportion of GDP, which is exogenous to the model. The rural production refers solely to the agriculture sector. This is a function of rural labor and its productivity, and the effect of soil moisture and rainfall.

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[16] This is a reasonable assumption given that in Mozambique, all villages and cities are classified as urban areas (using the administrative criteria). In most of these villages, the majority of the active population is occupied in traditional agriculture. This currently works as a pushing factor for people with some education to go the main cities of the country.

The skilled labor model

The basic assumption of our model is that an increase in the demand for skilled labor is determined by economic growth, while the elasticity of demand for skilled labor with respect to the real wage is very inelastic. The supply of skilled labor is determined by two factors: the size of the skilled population and the real wage rate. The size of the skilled labor force is influenced by factors such as population size, enrollment and graduation rates, and losses by death (particularly AIDS), emigration and retirement.

The demand for skilled labor, *D*, is a function of the size of the economic growth (GDP is provided by the above-mentioned economic model) and wage rate. When the economy grows, so does the demand for skilled labor. In Botswana, Kibuuka (1998) estimated that there was a 1% increase in the demand for skilled labor for each percentage increase in the economy. We call this demand shift elasticity, α.[17] In Mozambique, the estimations of the demand shift elasticity indicate that for each unit percentage change of GDP, there is a lower percentage change in demand for skilled labor of 0.49%. It can happen that this elasticity is heavily influenced by employment in the public sector.

The demand for labor responds to the wage rate. Some studies for selected countries have found a wide variation in the response (see Hamermesh (1993) for a summary of the studies). The average was a decrease of about -0.5% in demand for labor for each percentage increase in real wages. The estimate for Botswana was -0.6%. We call this demand wage elasticity, β.[18] For Mozambique the figure is estimated at -1.5%.

The demand for labor is then given by the formula:

$$D= k_d D_o^{\alpha} W^{\beta} \qquad (1)$$

where *D* is the demand, *K* is a constant, D_o is GDP, and *W* is the wage rate.

The supply of skilled labor, *S*, is a function of the level of supply of the total professional and technical workforce, S_0, and the wage rate, *W*. Demographic factors, enrollment/graduation rates, and migration determine the total professional and technical workforce. The demographic factor par excellence is population growth. The population of Mozambique is growing at about 1.9% annually, which means that each year a large number of people enter the workforce. Many young people entering the workforce are graduates of the university. Net migration also shapes the level of supply of skilled labor. Deaths and retirement decrease the labor force. In a normal situation, this is only a small percentage of the total labor force annually. But in the situation of a deadly epidemic, such as AIDS, a significant proportion of the labor force can die each year. In developing countries such as Mozambique, everybody who receives higher education enters the labor force. Therefore, our supply shift elasticity, γ, is 1. Wages have no effect on the decision to work in this model, so our supply wage elasticity, λ, is set at 0.

Our supply equation is given by:

$$S = S_o^{\gamma} W^{\lambda} \qquad (2)$$

In this model, the equilibrium point is the level at which the supply and demand for skilled labor is in equilibrium. Equating (1) and (2) above we have:

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[17] Demand shift elasticity (α) is the percentage change in demand per unit percentage change of GDP: 2056/3116*8822/11853=0.49.

[18] Demand wage elasticity (β) is the percentage change in demand per unit percentage change in wages: 1525/753*8822/11853=-1.5.

$$W = \left(\frac{k_d D^{\alpha}}{S^{\gamma}}\right)^{1/(\lambda-\beta)}$$

Table 10 summarizes the estimated model parameter values for 1991 and 1997.

Table 10. Values for wage model in 1991 and 1997.

	1991	1997
Wage, in million 1991 Meticais	1,525	0.754
GDP in billion 1991 Meticais	2,056	3,116
Skilled labor force in 1,000	8,822 (interpolated)	12,083
Demand from GDP exponent, α		-0.49
Demand from wage exponent, β		1.5
Supply from population exponent, γ		1.0
Supply from wage exponent, λ		0.0

Scenarios

In order to evaluate the future impact of HIV/AIDS on the future equilibrium demand and supply of skilled labor, we consider six scenarios:

1. **Base No AIDS**: This scenario presents the possible spectrum of skilled labor, in a situation where there is no AIDS.

2. **Low HIV Prevalence**: A relatively optimistic scenario of low prevalence rates stabilizing at 17%. This prevalence estimation has been used by INE, MISAU, and MPF to produce population projections with and without AIDS for Mozambique until 2020.

3. **High HIV Prevalence**: A pessimistic scenario with the prevalence rate rising to 35%. This rate was estimated by IIASA.

4. **Base No AIDS, Education Efficiency**: We reduce the drop out rate by 50% to examine the impact of education on the skilled labor market.

5. **Base No AIDS + Less Productivity**: Scenarios 1-4 use a very optimistic rate of productivity growth (3% per year).[19] Here, we try to see how output and wages behave at a lower growth rate of productivity of 0.72%. This is the case of Sri Lanka, a country with a roughly similar economic pattern.

6. **Low Prevalence + Less Productivity**: We combine the low prevalence from Scenario 2 with the lower productivity from Scenario 5.

7. **High Prevalence+ Less Productivity**: This case is similar to Scenario 6, but with high HIV prevalence from Scenario 3.

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[19] A study from Choudri and Hakua (2000) indicates that from a sample of 45 countries, only two countries managed to reach a productivity growth factor above 2% (Malta 3.67 and Cyprus 2.41).

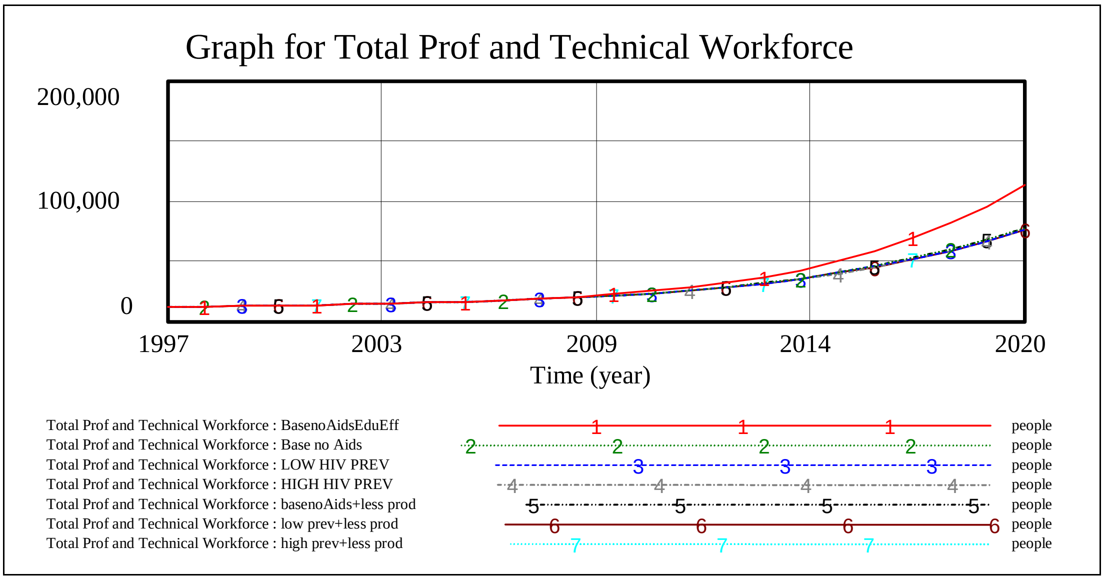
Main scenario results

Our basic finding is that skilled labor is less affected by HIV/AIDS as compared to the overall population. Without AIDS, the overall Mozambican population is estimated to reach 24.9 million in 2020. With a low HIV prevalence scenario, the projected population is 4.5 million less compared to the no AIDS environment in 2020. This is equivalent to a loss of 18% of the overall population. When a pessimistic scenario is utilized, the population loss is 6.6 million. This means that more than a quarter of the population would be lost as compared to the Base No AIDS scenario. In this case, Mozambique would start to have zero population growth in 2008.

In contrast, when we consider only skilled labor, the trends change significantly. Without AIDS, skilled labor increases from 12,000 to 77,300 in 2020. When we consider a low prevalence rate, skilled labor falls by 1,200 individuals in 2020. This is equivalent to a loss of only 1.5% of the skilled labor force in 2020. In a high prevalence environment, the difference to a No AIDS scenario is 1,600 individuals. This corresponds to 2.1% of losses just for the year 2020. Despite the lower impact of HIV/AIDS on skilled labor as compared to the overall population, the presented losses of skilled labor should not be discounted.

While the losses in 2020 are 1,200 for low and 1,600 for high prevalence rates, the *cumulative* losses are much deeper. In a low prevalence scenario the cumulative loss of skilled labor is estimated at 5,600 individuals; in a high prevalence scenario it is estimated at 7,300. Those are huge losses if we consider that the government spends over 40 million Meticais[20] per student per year to make higher education available to the country. It is only when we increase education efficiency that the size of the skilled labor force increases by more than 35,000 individuals compared to a no AIDS environment (see Figure 4).

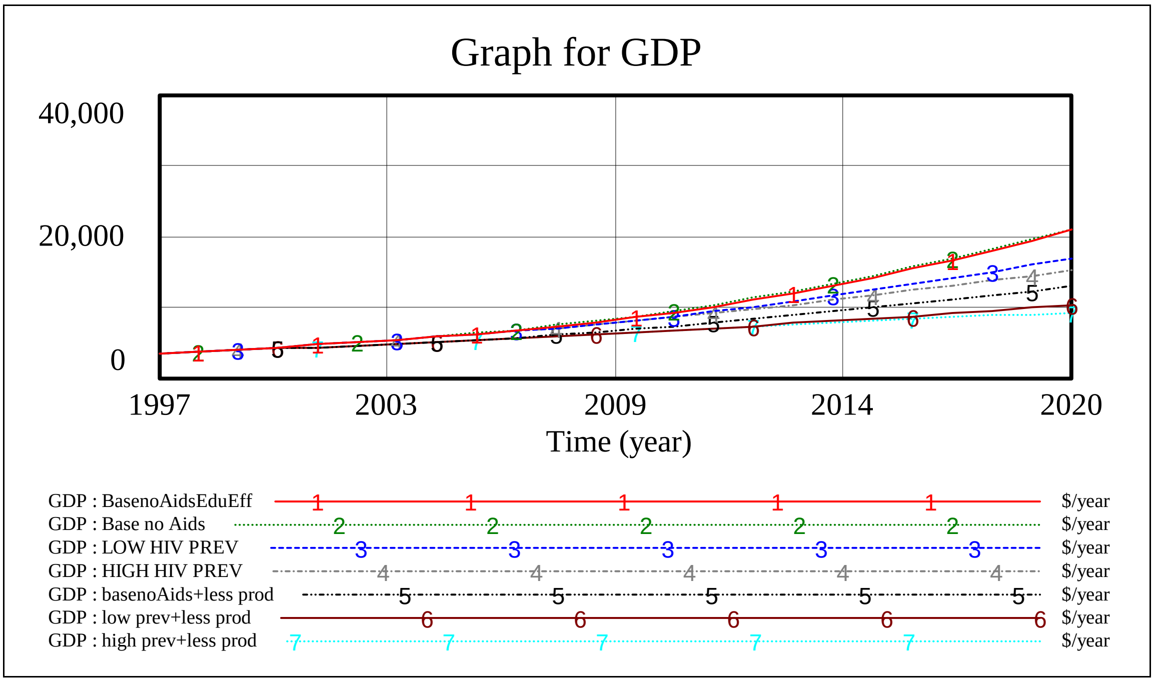
Figure 4. Total professional and technical labor force in seven scenarios.



[20] 1998 data. Estimations are based on the public budget for the two public universities in 1998 and the number of students provided by Instituto Nacional de Estatística (2000).

Moreover, HIV causes overall labor loss, which in turn, causes GDP to fall as compared to a No AIDS scenario[21] (see Figure 5). When there is no AIDS, high productivity growth and a greater supply of labor causes GDP to rise from around US$ 3,400 million to US$ 21,000 million in 2020. This would imply an average annual growth rate of 8% per year. Low HIV prevalence causes GDP to fall by around US$ 4,000 million, 19% less than a No AIDS scenario. This is because less total labor enters into the production function. When prevalence rates are higher, the economy is even more affected, causing the output level to be lowered by more than US$ 5,800 million, or 28% less.

Figure 5. GDP in Mozambique, 1997-2020, according to seven skilled labor force scenarios.



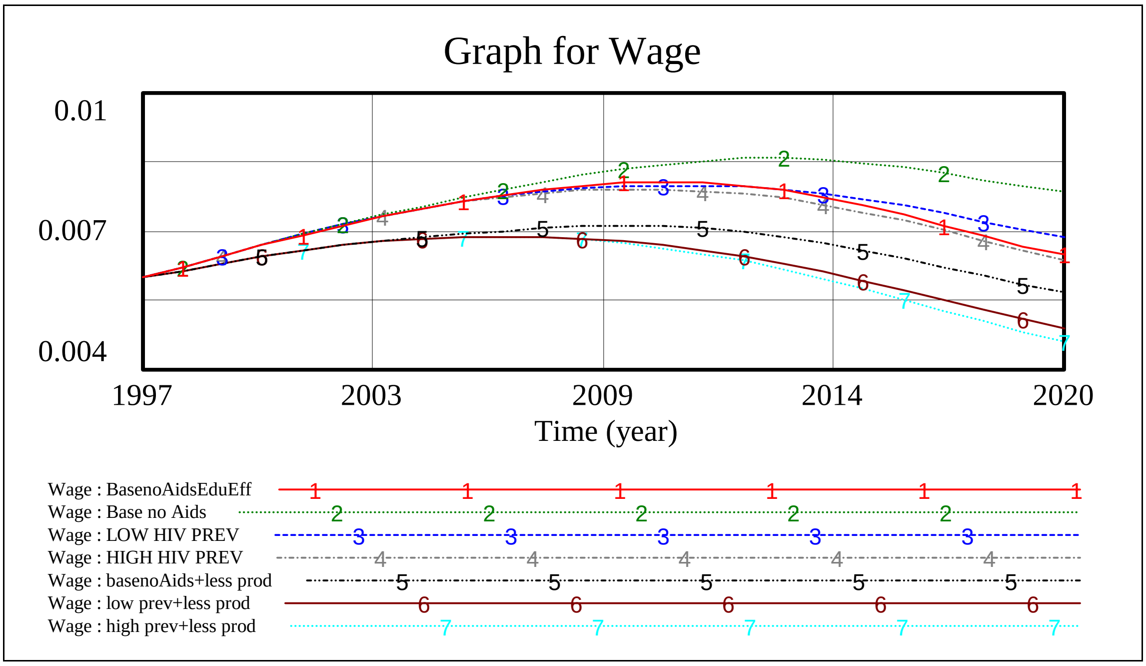
If we consider an environment where the productivity growth rate is low, then output grows at a lower rate. When there is no AIDS, GDP is lowered by US$ 8,000 million as compared to a scenario of high productivity: 39% less and 6% of the average annual growth rate. When low prevalence rates persist, the output in 2020 is around US$ 10,000 million. This would imply a more modest growth rate of the economy by 4.8% per year on average, in comparison to 8.1% if productivity were growing at 3% and there were no AIDS. Should high prevalence rates materialize, then GDP would be even lower: US$ 9,200 million. The implied growth rate of GDP would be 4.1%.

Our wage model for skilled labor is set up in such a way that wages are directly proportional to GDP growth and inversely proportional to labor supply. The effects that changes in the size of the labor force, productivity, and GDP growth have on the wage rates are shown in Figure 6. In Scenario 1 with no AIDS and high productivity, real wages rise from their initial level of around US$ 6,000 per year in 1997 to US$ 7,800 in 2020, an increase equivalent to 1.2% per year on average. The case of HIV/AIDS with a low

[21] The model is built to consider total labor in the production function. For this reason, it is not possible to estimate the isolated effect that skilled labor has on the economy.

prevalence rate reduces overall labor availability and output. Lower output growth causes a decline in skilled labor demand. However, real wages still rise, but at a lower growth rate (0.1%) as compared to a No AIDS scenario. With the High HIV Prevalence scenario, the real growth rate of the skilled labor wage rate actually turns negative, to an average of -0.2% annually.

Figure 6. Wage for the highly skilled professional and technical workforce in Mozambique, 1997-2020, according to seven scenarios.



The productivity factor seems to have a strong impact on the wage rate. We test again the impact of lower growth in productivity. Consider the low and high prevalence rates of HIV. Under these scenarios, the size of the skilled labor force involved in production is the same as in a high productivity scenario, but output worsens. In this case, the skilled labor supply will be rising more quickly relative to labor demand, because the economy is growing more slowly. The decline is more severe with high HIV prevalence (-1.3%) than with low HIV prevalence (-0.9%).

Another case where the increase in skilled labor supply dampens the real wage arises when we increase the efficiency of the education system, even though we maintain a higher growth rate of productivity. This happens because there is an inelastic wage demand, so rising labor supplies lower wages. Under this scenario, skilled labor rises by 10%, while the economy grows at 8% between 1997 and 2020.

Figure 6 shows that real wages for skilled labor will increase in the medium run, but not in the long run. In the worst scenarios (low and high prevalence combined with low productivity growth) real wages begin to decline around 2005. In the best scenario, with no AIDS and high productivity growth, skilled labor wages rise until after 2010. The reasons for the later wage decline are a combination of the high exponential growth of the skilled labor force, HIV/AIDS, and lower productivity gains. The results are summarized in Table 11.

Table 11. Scenario outputs for the year 2020.

Scenario	GDP in million 1995 US$	GDP per capita in 1995 US$	Skilled labor (no. of workers)	Skilled labor wages (index)
Base No AIDS	20,921	837	77,246	0.0078
Low HIV Prevalence (17%)	16,976	833	76,076	0.0068
High HIV Prevalence (35%)	15,107	836	75,645	0.0063
Base No AIDS, Education Efficiency	20,961	842	112,589	0.0064
Base No AIDS + Less Productivity	12,890	516	77,275	0.0056
Low Prevalence + Less Productivity	10,279	511	76,008	0.0048
High Prevalence + Less Productivity	9,267	506	75,645	0.0045

Conclusions

There is a dire shortage of skilled labor in Mozambique at the present. Only 0.07% of the active labor force has a bachelor or more degree of education. If the post-war economic recovery is to continue, particularly in the urban areas, an increase in skilled personnel to manage an increasingly complex society is necessary.

HIV/AIDS has serious negative impacts on the skilled labor force. The loss of skilled labor undermines a significant part of the government's efforts to improve human capital in the country. Total labor loss by HIV reduces the level of output in the national economy; this in turn affects the level of demand for skilled labor and its wage rate. Even without AIDS, the challenges that the government faces in its objective to reduce poverty by half by 2010, are huge. First, the government considers that this objective can be achieved through a rapid GDP growth rate, above 8%. Even though our scenarios include the possibility of an 8% increase in GDP, we must take into account that this can only happen through a high growth rate of productivity. But, as was mentioned earlier, very few countries manage to reach such a high rate of productivity growth, not to mention the GDP growth rate. Second, the government will have to take into account that fluctuations in GDP growth may occur because of the country's propensity to be affected by natural disasters. The country has already faced floods in the year 2000. These floods imposed a decline in GDP growth from 7.3% in 1999 to only 2% in 2000.

Taking into account the spread of the HIV pandemic, it is found that the government's objective of poverty reduction can be even more strongly compromised. Low HIV prevalence causes GDP to fall by 19% as compared to a No AIDS scenario with high productivity. This is because less total labor enters into the production function. When prevalence rates are higher, the economy is even more hit: the output level is lowered by 28%. Because the size of the population is also lower with AIDS, the effect on overall per capita income (according to our simplified economic model) is small.

The effects of the productivity factor are much stronger than the effects of AIDS. Low productivity causes GDP to fall by more than US$ 2,000 million as compared to an environment of high prevalence rates. The implication of these scenarios is that even though the government needs to control the HIV/AIDS issue, further steps need to be taken in order to sustain education achievements and technological changes in production. There is also a need to ensure that investment accrues in the country. Higher investment levels can boost the levels of labor demand and output.

Labor shortage due to HIV/AIDS does not necessarily imply higher real wage rates, particularly for the skilled labor force. One of the most interesting outcomes of the model is that the skilled labor force is much less reduced by AIDS than the overall labor force. The explanation lies in the age structure of the highly educated: most of them are very young adults (78% are under 40), in age groups where the HIV virus is still incubating, and deaths from AIDS are only beginning to occur. The uneven loss rates (higher for the overall labor force than for the skilled labor force) mean that skilled labor becomes *relatively* more abundant. A smaller overall labor force contributes to losses in total production. A lower growth of production constrains the expansion of skilled labor absorption and reduces the income available to pay them. Thus, HIV/AIDS could depress the income of the highly skilled workers.

How might policy makers (usually highly skilled) ensure that skilled labor wages do not decline as a result of a desirable accelerated growth in the supply of skilled labor? Classic measures include enhancing overall productivity and increasing investment rates. Another would be to shift the *structure* of the economy towards services, which require young, highly skilled workers, for example, tourism guides, computer programming, translation, and teaching. A third policy, which arises from the results of this paper, would be to combat the HIV/AIDS epidemic in the general population.

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AGRICULTURE AND HIV/AIDS IN MOZAMBIQUE: A DISCUSSION

Isolde Prommer

Introduction

Mozambique is a large, semi-arid to sub-tropical country in the southeastern region of southern Africa, with a wide range of biodiversity and high HIV infection rates (16% of adults aged 15-19 are HIV positive; Wils et al. 2001). This paper discusses the prospects of agricultural development in Mozambique at the beginning of the 21st century within the HIV/AIDS pandemic, which is of widespread concern in Mozambique and sub-Saharan Africa. The study reviews the relevant literature in English, Portuguese, and German, obtained from on-line sources as well as from international libraries, and is in no way a fully comprehensive analysis of the issue. Less attention was given to the interrelationship between the epidemic and agricultural development on a large scale.

The first section describes the natural conditions, which are the basis for agricultural production. Major environmental changes, which would make the environment increasingly vulnerable, are expected to take place. The second section gives the history of agricultural production on the national level and focuses on the production systems of the majority of the rural farmers, the family farms sector, by province. It will be increasingly necessary to maintain components of the varied traditional management systems to minimize environmental deterioration and keep biodiversity as a secure basis for the poorest farmers in the country, especially in the era of HIV/AIDS. The third section summarizes the known impacts of HIV/AIDS on agricultural production and farming systems in the southern African region, made available by a number of empirical case studies and surveys. Finally, conclusions are drawn. The future of Mozambique's agricultural production potential and food security will depend on adopting governance systems that strengthen local-level mechanism and institutions and the links between knowledge, resource managers (farmers), policy makers, NGOs, and other stakeholders.

Natural Conditions and Demographic Indicators

Mozambique is situated between latitudes 10°7' and 26°52' south and longitudes 30°12' and 40°51' east. It comprises 799,380 square kilometers and has a shoreline on the Indian Ocean of about 2,470 km in length, which is generally sandy and bordered by lagoons, shoals and strings of coastal islets in the north (Gaspar et al. 1998). The country is characterized by a wide diversity of habitats.

Geophysically, the country can be divided into four main land zones:

(a) From the coast to the interior and along some rivers, the plains lie at an elevation of under 200 m and cover more than 40% of the land area. North of the Zambezi River, the plains are between 60 km and 100 km wide. In the Zambezi Valley the plains extend upstream about 600 km. South of the Zambezi River the plains are up to 100 km wide. The coastal area is divided into different sections. The northern part is composed of craggy coasts. In the Zambezi Delta and in the southern area, beaches interrupt mangroves.

(b) A lower and middle plateau, covering about 30% of the land area, extend from the plains in the west (elevation 200 m to 500 m). The biggest area is located in the north of the country.

(c) The middle plateau (elevation 500 m to 1,000 m) covers approximately 26% of the land area and is located in the western part of northern and middle Mozambique.

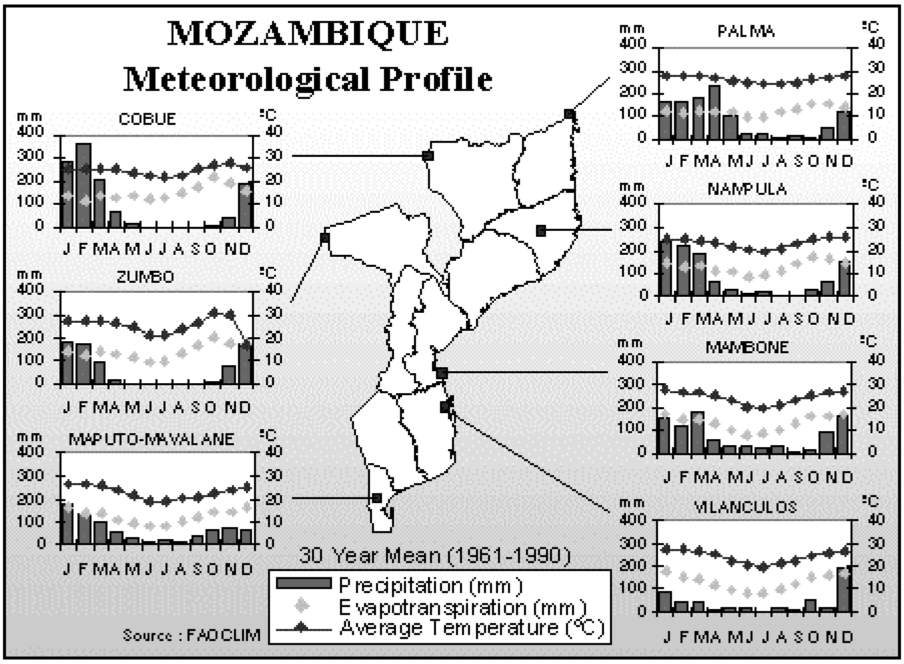
(d) The remaining area is mountainous (with elevations above 1,000 m) and accounts for about 5% of the land area. The mountains of Alto Niassa, Alta Zambézia and Agonia are of importance. The highest point in Mozambique is Monte Binga at 2,436 m.

All of these main land zones are not unique in terms of soils and micro-climate conditions.

About 25 main rivers flow through the country to the Indian Ocean. The largest and most important is the Zambezi River in central Mozambique, the fourth longest river in Africa. Of the 820 km in Mozambique, 420 km are navigable. North of the Zambezi River, important sources of water are the Rovuma (650 km), Liganha, Lúrio (605 km), and Lugenda Rivers. South of the Zambezi River, the Pongue, Buzi (320 km), Limpopo, Save, and Komati Rivers are important resources.

The climate can be described as semi-arid in the south to sub-tropical in the north. The country is affected by the seasonal air circulation of the Indian Ocean and is characterized by one rainy and one dry season per year. The Northern Provinces have a monsoon climate with rainfall between December and March. The Southern Provinces have larger differences in temperature and precipitation. The heaviest rain falls between October and March (see Figure 1).

Figure 1. Meteorological patterns in Mozambique, average 1961-1990. Source: SADC/FSTAU – FAO/GIEWS (2001a).

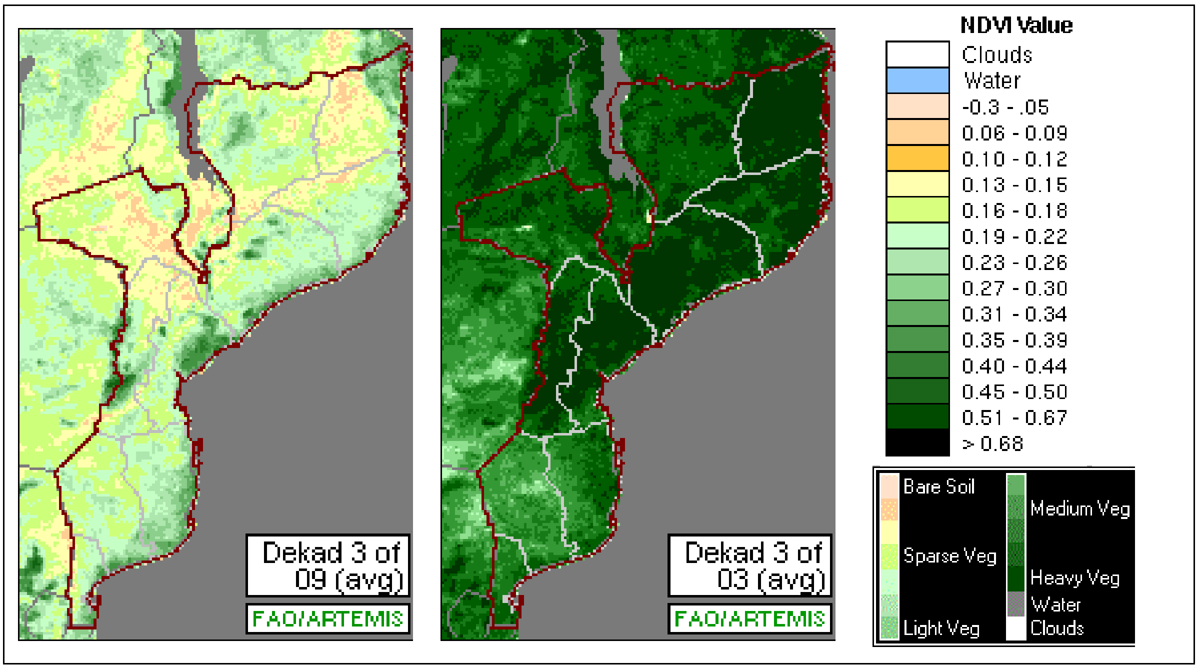


Based on Figure 1, we can analyze the growing conditions, such as the length of the rainy and dry seasons, or the months of water stress and water availability as expressed in the graphs by the evapotranspiration curve (light gray dotted line). We can see that in many regions without irrigation no second cropping season is possible. The limiting factor is water, not temperature.

The whole country is suitable for agricultural production in terms of the length of the growing period, which is 120 to 328 days per year. The highest suitability is in the plains of the Zambezi Valley and Sofala Province. Lower suitability is in the mountainous areas of Tete, Cabo Delgado and Niassa. The “hot spots” in east Gaza are exceptional with a very short growing period of 30-59 days (FAO/IIASA 2000; Fischer et al. 2000).

Another common indicator for analyzing growing conditions is the photosynthetic activity of the terrestrial vegetation. This is done by NDVI, which is gained from satellite images. The NDVI index is a helpful instrument for the analysis of weather conditions for the current cropping period based on comparisons of historical conditions. Figure 2 shows the mean NDVI index for Mozambique at the end of the dry season (mean value September) and at the end of the rainy season (mean value March) for the period 1982-1998. The darker the area on the map, the more green and densely vegetated the area.

Figure 2. Normalized Difference Vegetation Index for Mozambique, average 1982-1998 (Dekad 3 of 09 refers to September and Dekad 3 of 03 refers to March). Source: FAO/ARTEMIS (2001).



According to the FAO/IIASA study (2000), the general soil conditions for crop systems are good: (i) *soil depth* constraints exist partly in Tete Province and in the eastern part of Gaza Province; (ii) for *soil drainage* and (iii) *soil chemistry*, very few and few constraints are documented in Niassa Province, in the Zambezi Delta and in coastal Inhambane; (iv) few and partial *soil texture/stoniness* constraints are found throughout most of the country; and v) within the mountainous and hilly areas, frequent severe *terrain slope* constraints are common.

Figure 3 shows the distribution of the combined soil, climate and terrain slope constraints for Mozambique. The biggest limitations, classified as "unsuitable for agriculture" are in the Province Zambézia; "frequent and severe constraints" are in the mountainous areas of the Provinces Niassa and Cabo Delgado. Those production limitations are mainly due to serious soil fertility, and partly due to soil drainage (frequent and severe category) and texture constraints (unsuitable category). The 'severe climate constraints' in eastern Gaza are due to moisture constraints. Generally, climate conditions, soil chemistry, and soil drainage conditions are good throughout Mozambique.

Figure 3. Climate, soil, and terrain slope constraints combined for Mozambique. Source: FAO/IIASA (2000: Plate 28).

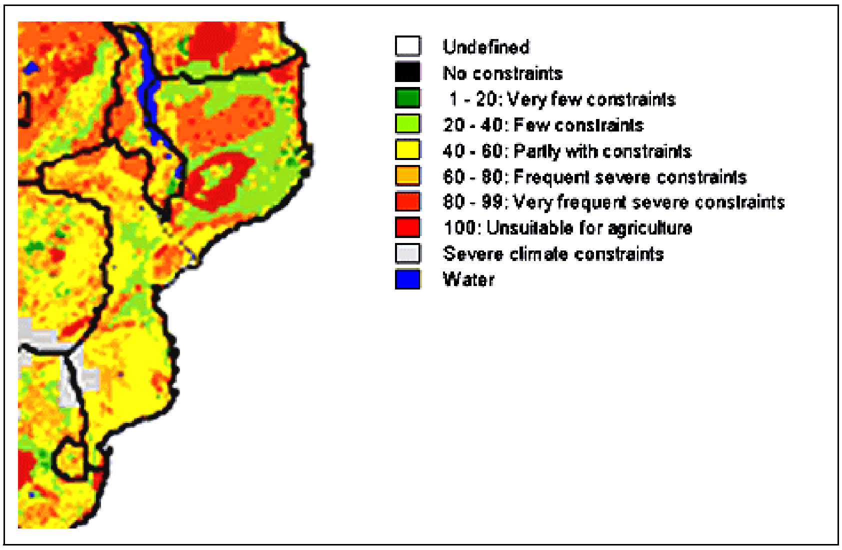


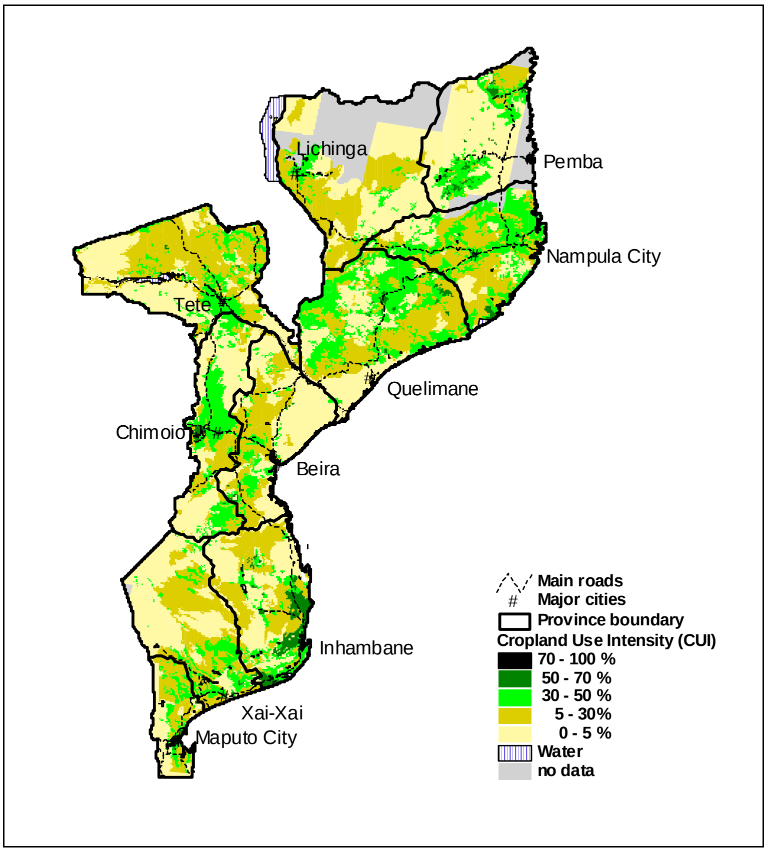
Figure 4 shows the cropland use intensity for Mozambique, evaluated by satellite images, interpreting agricultural land use change over the period 1986-1988.[22] The map shows the percentage of land area used for cropping within each grid space. The highest CUI (70%-100%) occurs along the main infrastructure network and urban agglomerations.[23]

Compared with the NDVI map (Figure 2), in areas with high variation in vegetation growth, such as western Gaza and Tete, the CUI is very low (below 5%). Other regions with low CUI are either sparsely populated or mountainous, or are areas with low soil fertility and other soil constraints (Figure 3), or are badly connected to the infrastructure (Figure 4).

[22] The land use inventory for Mozambique showed high correlations between cropland use intensity and population density.

[23] The transport infrastructure includes only the major roads. Additionally, the hinterland is more or less only accessible via unpaved roads or footpaths.

Figure 4. Cropland use intensity in Mozambique, 1986-1988. Source: EROS Data Center/USGS (1992). Note: Province map, cities and main roads have been added by the author.

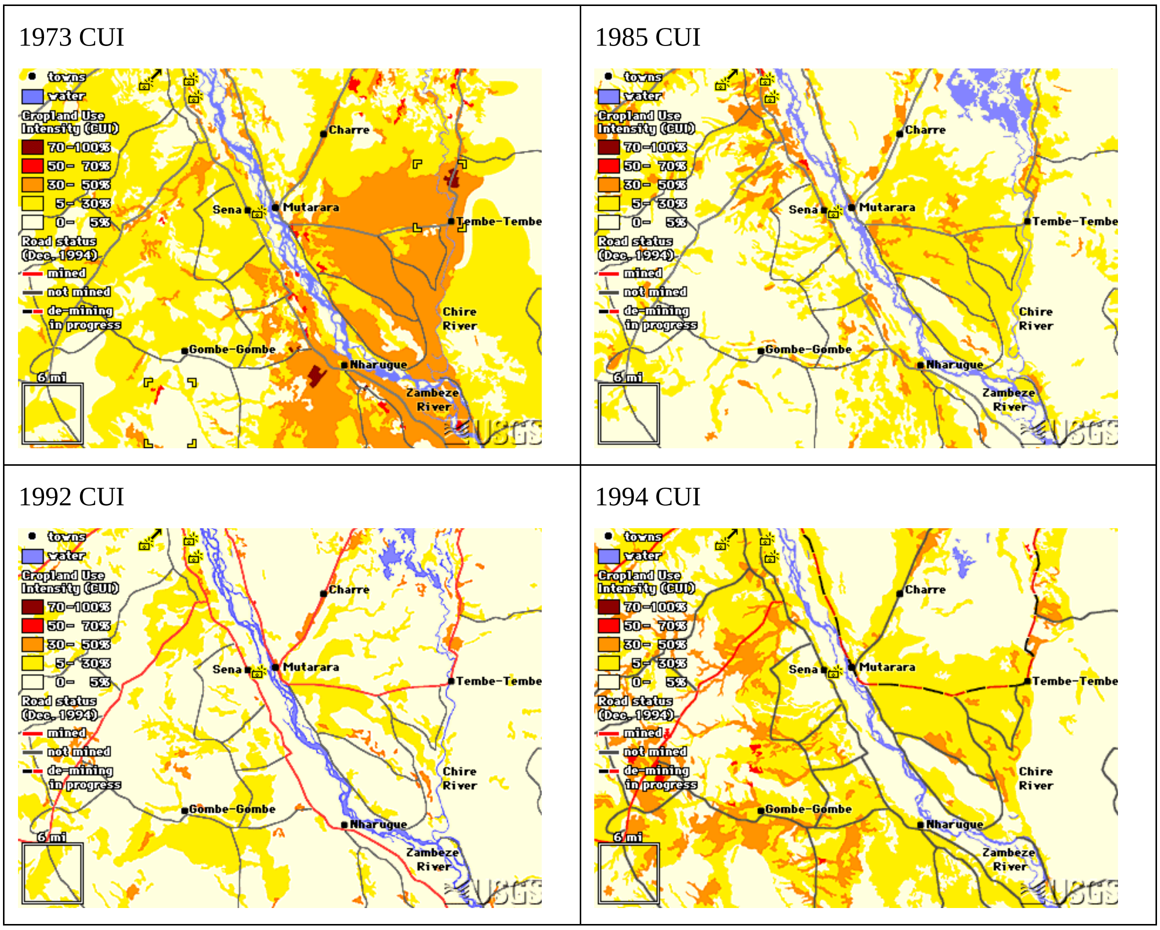


The USGS (1995a) CUI pilot study of the Mutarara/Sena area[24] (see Figure 5) shows the development of the (i) cultivation pattern before independence (April/May 1975), (ii) followed by the post-independence agricultural practices (which were affected by the departure of colonial companies) before war-related destruction and de-population (April/May 1985); (iii) the near-maximal population displacements and drought year (April/May 1992); and (iv) the postwar land use pattern and influx of the returning refugees (April/May 1994). The time series show huge differences in the utilization of land for agriculture (the darker the color, the higher cropland use intensity). The devastating effects of war are clearly visible in the strong decline in both land utilization density and total cropped area during the civil war period, followed by an intensification since the Peace Agreement in late 1992. For instance, in 1973, 16% of the study area was under cultivation. In May 1985, the amount of cropped area is estimated to have been 43% of the area cropped in 1973. Where the CUI range had been 30%-50% before independence, it was generally reduced to between 5%-30%. Areas with a CUI range between 5%-30% were still uncultivated ten years after independence. The CUI

[24] The area includes the towns of Mutarara and Sena in central Mozambique and portions of the Zambezi and Chire Rivers (parts of the Provinces Sofala and Zambézia). The area was studied for several reasons: (i) it is one of the most densely populated areas of the country; (ii) it has good soil and climate conditions; (iii) it was connected by railway to the port of Beira (this railway line has not been reactivated to date); (iv) it was heavily affected by the civil war in terms of refugee and repatriation movements to and from the neighboring Malawi; (v) during the colonial period the area was an important cotton producing center, and (vii) after the Peace Agreement, it was one of the areas with severe food shortages.

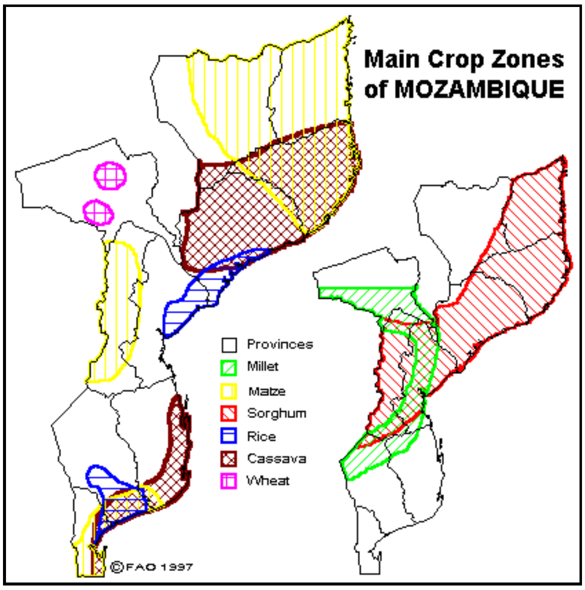
interpretation of 1994 images indicates that the percentage of the study area under cultivation increased to about 10%. Most of the areas cropped between 30%-50% in 1994 were west of the Zambezi River (USGS 1995a, 1995b).

Figure 5. Cropland use intensity, Zambezi Valley, 1973-1994. Source: USGS (1995b).



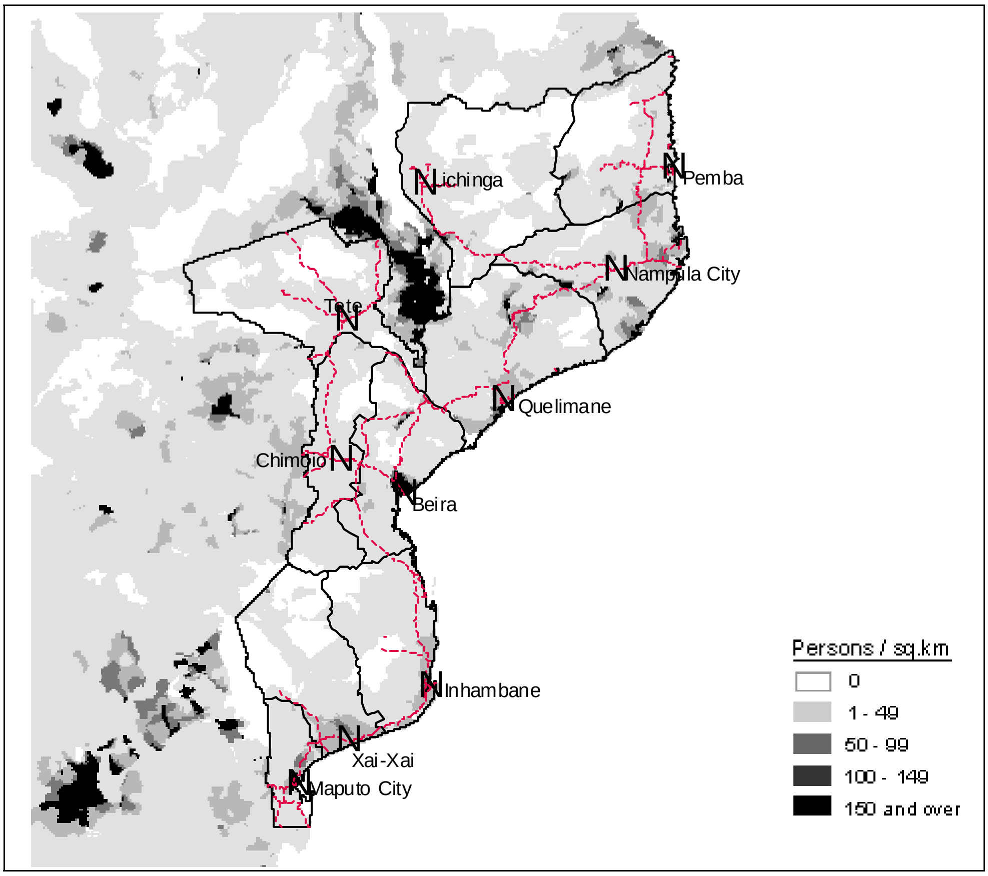
The geographical distribution of the suitability to specific crops depends on natural conditions such as precipitation, plant growth capacities and its variation spectrum (NDVI), soil type, soil fertility, temperature, and others as described above, as well as on socioeconomic, traditional, and institutional conditions (man made environment). The FAO (2000c) provides a cropping zone map for Mozambique (see Figure 6) on its website. The map refers to crop suitability. The website does not provide any information on whether the map has been developed on the basis of suitability due to natural conditions, or if it is based on rainfed or irrigated crops. Furthermore, no information is available on what input level has been taken into consideration. It can be assumed, by comparing this map to the FAO/IIASA (2000) information, that it is based on suitability for rainfed crops at medium input level. This simplified FAO map does not reflect the actual spatial crop distribution.

Figure 6. Main crop zones in Mozambique. Source: SADC/FSTAU – FAO/GIEWS (2001b).



When we compare the cropland use intensity map (Figure 4), which includes the major infrastructure, the climate, soil, and terrain slope constraints map (Figure 3), and the NDVI maps (Figure 2) with the population density map (Figure 7), we can see that the population distribution reflects natural conditions.

Figure 7. Population density in Mozambique, 1990. Source: UNEP/GRID (2001).



In terms of demographic indicators, Mozambique is a typical example of a developing country. Regarding the age structure, a large portion of the population is young: 44.8% of the population is younger than 15. The lowest proportion is in Maputo City (40.5%) and the highest in Tete Province (48.2%) (Instituto Nacional de Estatística 1999; Gaspar, this volume). The combination of the high total fertility rate, which results in a young population, and the HIV/AIDS pandemic will be an important political challenge for the country's economic and agricultural development.

Regarding economic activity, the majority of the population lives in rural areas and is active in agriculture, forestry and fisheries (see Table 1; Instituto Nacional de Estatística 1999); 90% of the rural population is dependent on agricultural activities. Women are practically exclusively dependent on agricultural activities throughout the country. Moreover, in urban areas occupation in agriculture and fisheries is still common and provides either additional household income and food supply in addition to a formal occupation, or it is the only source of income (food and monetary). In urban areas, the number of people who are economically active in agriculture, forestry and fisheries out of a total economically active population ranges from 27.6% in Maputo Province to 66.7% in northern Cabo Delgado. The respective numbers in rural areas are much higher, between 81.8% in Maputo Province and 95.4% in Cabo Delgado. Economic activity outside the agricultural sector in rural areas is low for both sexes, but much lower for women. The best off-farm employment opportunities are in urban areas, particularly in Maputo Province and Maputo City.

The sex ratio (man per woman) of the economically active population in agriculture shows a completely different pattern (see Table 1). According to the official statistics, in Mozambique, twice as many women as men are economically active in agriculture, forestry and fisheries in urban areas. The situation in rural areas mirrors the same pattern with slightly lower differences. In the urban southern provinces, up to four times more women than men, in the central provinces slightly less than twice as many females (with the exception of the most urbanized central province Sofala, which mirrors the situation of the southern provinces), and in the urban northern provinces around one-fourth more women than men are occupied in the agriculture, forestry and fisheries sectors. The situation in rural areas is similar with a slightly lower gender gap of about twice as many women as men in the southern provinces, about one-fourth more women in the central provinces, and about one-seventh more women in the northern provinces.

This gap shows that the poorest in the country are the women in the agricultural sector. This reflects the overall situation in southern Africa. Compared to the sex ratios by province, it is evident that larger portions of the female population are economically active in the primary sector in provinces with very high male out-migration rates (southern provinces) than in provinces with lower labor mobility rates (northern provinces). The population of the southern provinces is already characterized by very low sex ratios due to the high male labor out-migration to neighboring countries and to urban areas (Gaspar, this volume). The sex ratio, for instance, for the total rural population is 0.60 in Gaza and 0.50 in Inhambane Province. Labor mobility is one of the strategies of poor rural households to diversify risk and to secure the basic needs for daily life. In part, mobility is responsible for the fast spread of the HIV/AIDS pandemic in sub-Saharan Africa, and especially in Southern Africa. We have to consider that the poor are not only income- and asset-poor, but they also lack the characteristics of education and good health that are important for a modern economy and society. "It is scarcely surprising that the group experiencing the fastest rate of growth of HIV infection worldwide is women, with in many countries rates of infection in young women under the age of 20 some 5 to 6 times those of young men" (Cohen 1998:5). The behavior that exposes the poor to HIV infection also limits their ability to cope with infection: their lack of assets/savings; the vulnerability and uncertainty of sources of income; their lack of access to knowledge about the process of infection, including an understanding of opportunistic infections; and their general lack of access to health and other support services.

Table 1. Percentage of the population who are economically active in agriculture, forestry and fisheries, of the total economically active population aged 15 years and over in 1997. Source: Instituto Nacional de Estatística (1999: Table 7.4).

	Urban				**Rural**			
	Total %	**Male %**	**Female %**	**Sex Ratio**[1]	**Total %**	**Male %**	**Female %**	**Sex Ratio**[1]
Niassa	64.5	49.5	85.6	0.82	93.8	89.7	97.8	0.91
Cabo Delgado	66.7	49.3	89.9	0.73	95.4	91.8	98.7	0.84
Nampula	56.8	39.1	86.9	0.77	94.6	90.0	99.0	0.87
Zambézia	58.9	39.2	86.7	0.64	93.3	87.5	98.4	0.77
Tete	44.7	27.5	71.9	0.60	94.1	90.0	97.7	0.81
Manica	39.5	24.9	66.4	0.69	88.1	79.4	95.5	0.72
Sofala	39.0	17.3	72.8	0.37	88.7	78.7	97.1	0.68
Inhambane	53.0	34.7	68.2	0.42	90.4	80.5	96.3	0.50
Gaza	63.8	34.6	81.6	0.26	91 .9	80.5	97.5	0.41
Maputo Province	27.6	12.4	47.2	0.34	81.8	69.3	91.4	0.58
Maputo City[2]	9.6	5.2	16.6	0.49	-	-	-	-
Mozambique	*41.0*	*25.1*	*63.1*	*0.55*	*92.7*	*86.6*	*97.8*	*0.73*

[1] Calculated by the author from the total number of people employed in the agriculture, forestry and fisheries sectors.
[2] 100% of the Maputo City population is classified as urban.

Population density roughly doubled by total agricultural area in the period 1960 to 1997, from 14.2 persons per km^2 to 34.0 persons per km^2, but these are concentrated in dense pockets of cultivation.[25] The Ministry of Agriculture and Fisheries (personal communication, Mr. Domingos Diogo 1998) quotes the amount of potential agricultural area as 36 million hectares, which is similar to the FAO (2000a) figures. Further, according to the Ministry, in 1997 only 4.7 million hectares were actually cultivated, i.e., 13% of the potential area (personal communication, Mr. Diogo). This means that population density in the cultivated areas – supposing that the whole population lives in real cultivated areas – was 342.5 persons per km^2 in 1997. In other words, the per capita cultivated area was 0.29 hectares in 1997. According to the FAO (2000a), 3.35 million hectares (classified as permanent and arable land) were under cultivation between 1992 and 1998; the population density of the area was 480.6 persons per km^2; and per capita cultivated area was 0.21 hectares in 1997. With these values, Mozambique would lie between the high input and mechanized agricultural systems of North America and Europe. For example, the United States has a density of 149 persons per km^2 and 0.67 hectares of cultivated land per capita, and Germany has 678 persons per km^2

[25] The figures for 1965 were calculated from the 1960 total population of 6,603,653 (Gaspar 2001). The FAO total agricultural area in 1961 was 46,649,000 hectares. The figures for 1997 were calculated from the 1997 census showing a total population of 16,099,246. The FAO total agricultural area in 1997 was 47,350,000 hectares.

and 0.15 hectares per capita. Mozambique's figures are very close to its former colonial power of Portugal, which has 364 persons per km^2 and 0.27 hectares per capita. But Mozambique has substantially smaller yields than these countries, e.g., 830 kg/ha for cereals compared to 6,000 kg/ha in the U.S., which explains parts of the food insecurity in Mozambique.[26]

Labor migration and its history should be kept in mind (for more details, see Gaspar, this volume), when we discuss the potential of agricultural development. The country experienced almost three decades of war and civil strife, which ceased in late 1992 with the signing of the Peace Agreement. Hence, the total number of displaced people and refugees is the largest in Africa, and the third largest in the world after the Afghans and Palestinians. According to official data, about 1.7 million refugees fled to the six neighboring countries (mainly to Malawi) and an estimated 4 million people were internally displaced. Many of them were small-scale farmers who had sought sanctuary in the relative safety of the urban areas (for instance, in the provincial capitals, Maputo City, and the Beira corridor). Practically all of Mozambique was affected by refugee movements during the war, and by the influx of returnees after the war (UNHCR 1998, 1995).

Production of Selected Crops from 1961 to 1999

The agricultural sector in Mozambique is divided into the family sector, which cultivates about 93%-95% of the area, and the commercial sector, which is divided by the Ministry of Agriculture and Fisheries into state farms, private, and mixed farms (personal communication from Mr. Diogo in 1998).[27] Crop composition, total harvested area, yields, and total production in metric tons are characterized by significant changes over time, especially during the long lasting civil war period. This section describes the overall national production development and provides a short description of the family farm sector.

The governmental development planning strategies have changed several times since independence in 1975. They had to deal with the heritage of the Portuguese colonial system. Upon independence the government recognized the importance of the development of the agricultural sector – the mainstay of the country's economy. During the first years of independence the government focused on the development of the state farm sector. During the whole civil war period, most of the development investments in the agricultural sector went to the state and commercial farm sectors, and the family farm sector was neglected. Since the Peace Agreement in 1992, the Ministry of Agriculture and Fisheries has focused on the development of the family farm sector (e.g., Hanlon 1996; Wenzel and Weyl 1992).[28] Since the 1980s Mozambique has been faced with several structural adjustment programs of the World Bank and IMF. Governmental programs were established, such as the 'Economic Rehabilitation Program' from 1987 to 1989, the 'Mozambique Emergency Program,' the 'Priority District Program' in 1989, and the 'Comprehensive Program for the Agricultural and Natural Resource Sector' (PROAGRI) in the late 1990s.

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[26] Calculated from data in FAO (2000a) and United Nations (2000).

[27] The official figure for arable land in Mozambique is 36.6 million hectares, i.e., 47% of the total land area.

[28] Agrarian policies are not discussed in this chapter. See, for example, Braun 1989; Davison 1988; Dejene and Olivares 1991; Hanlon 1986, 1984; Hillebrand 1990; Meyns 1988; Rauch 1990; United States Department of Agriculture 1980; Weyl 1990; World Bank 1990, 1989; Wuyts 1989; and PROAGRI publications by the Republic of Mozambique.

Major staple and cash crop production according to FAO data[29]

The country's most important food crops are maize (*milho*), millet (*mapira)*, sorghum (*sorgo*), rice (*arroz*), cassava (*mandioca*), sweet potatoes (*batata doce*), potatoes (*batata reio)*, and to a certain extent wheat (*trigo*). It is notable that sorghum is not listed in the national Mozambican statistics but plays an important role in the FAO statistics. Cassava is, in terms of calorie intake, presently the most important crop, as it provides 36% of the total calorie intake on the national level. Maize, the next most important crop, provides 29% of the total calorie intake. It is followed by wheat and rice (5% each), and sorghum and millet (5% together) (FAO 2000b). The calorie intake composition differs from region to region, depending on the farm systems and cropping patterns, which in turn depend on natural conditions. Other factors that influence calorie intake are household composition and socioeconomic factors such as tradition, access to markets, and storage possibilities. Most of the calorie intake from wheat comes from imported wheat: it is a negligible crop in terms of domestic production. The major vegetable crops are beans (*feiões*), tomatoes (*tomate*), and onions (*cebola*). The vegetables are grouped in the national statistics as *hortículas*. Along the coastal areas in the Provinces Gaza, Sofala and Zambézia, rice cultivation is common in the plains, which are adaptable for rain-fed rice production.

The total production of the most important staple crops, roots and tubers, shown in Figure 8, increased after the end of the civil war in 1992. By contrast, most cash crops continued to stagnate. This may be the result of the focus of the government and development cooperation agencies to ensure food security before increasing the productivity of the cash crop sector, and/or the resistance of the local population to planting "colonial crops."

Figure 8. Total production of the main staple crops in 1,000 metric tons in Mozambique, 1961-1999. Source: FAO (2000a).

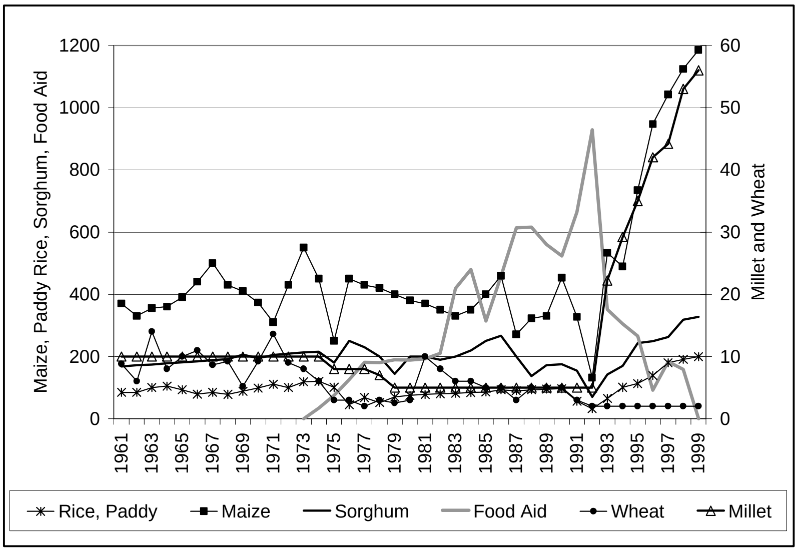


Figure 8 also shows the total amount of cereal food aid that arrived in the country between 1974 and 1998. At the peak of the food aid in 1992, 929,089 metric tons of cereals arrived, compared to only 132,047 Mt of locally grown maize. In total, four times as much food aid arrived in the country in that year than cereals were produced. Two factors led to the

[29] All data in this section come from FAO (2000a) unless otherwise stated.

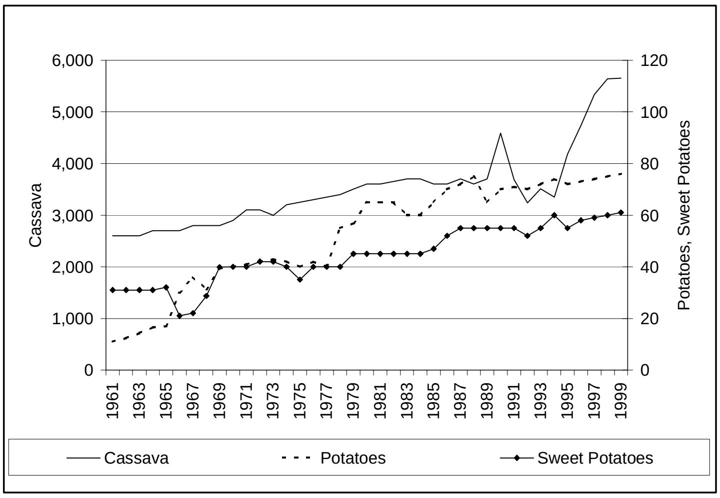
food shortage crisis. Historically, 1992 saw one of the most severe droughts, and the civil war had, by that time, displaced about one-third of the total population. This lead to a significant reduction in yields per hectare and total harvested area for all staple crops. These factors resulted in a reduction in seed availability, which made the planting of the same area as the year before almost impossible. From 1992 onwards, however, food aid declined precipitously, reflecting the rise in local production, better food distribution, and slow reconstruction of the markets and infrastructure.

At first glance, total production of the two most important staple crops, maize and millet, increased astoundingly after 1992. Compared to the mean production of the pre-independence period (1961-1974) and civil war period (1975-1992), maize production tripled and millet production increased 5.6 and 10 times, respectively. The per hectare production in 1999 for maize and millet reached approximately the same level as reported in the colonial period (0.94 Mt/ha for maize and 0.54 Mt/ha for millet in 1999, mean value of 0.92 Mt/ha and 0.53 Mt/ha in 1961-74) after a constant decline during the war period (0.16 Mt/ha for maize and 0.29 Mt/ha for millet in 1992). According to the FAO (2000a), the harvested area increased from 425,000 ha in 1961 to 1,260,000 ha in 1999. Millet shows the same pattern. That means that the steep increase of total production after 1992 is the combined result of yield increases and the increase of total harvested area.

Other staple crops, such as wheat and rice (paddy), have not shown a significant increase over the last ten years. In fact, wheat decreased constantly, both in production and in harvested area, from about 10,000 Mt to 2,000 Mt in the 1990s. Production declined sharply after 1975 and reached its peak in 1981. The steep reduction from 1971 to 1975 resulted from a sharp decline in yield, not from fewer harvested areas. The sharp increase in 1981 and 1982 was due to the national state-farm policies, and this level has remained constant.

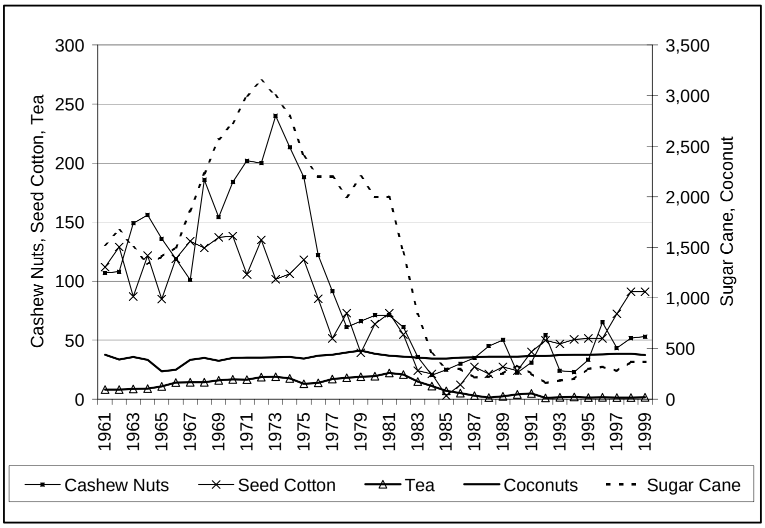
The production of cassava, sweet potatoes and potatoes increased constantly between 1961 to 1999 with almost no visible impact of the civil war (see Figure 9). Furthermore, there are no significant signs of drought or flood impacts, except for cassava in 1992-1994, but this was also related to a reduction in harvested area in 1993-1994. It is important to note that the increase in cassava production is based more on an increase in yield (Mt/ha) than on the harvested area, and the potential for higher yields still exist. The improvement of cassava, both in terms of productivity and nutritional value, is one of the main targets of the FAO (for more information, please see http://www.fao.org/NEWS/2000/000405-e.htm). In addition, sweet potatoes can be combined seasonally with rice. According to FAO data, the harvested area for sweet potatoes stagnated from 1976 to 1991, with a slight increase after 1995, following a reduction during the drought years.

Figure 9. Total production of main root crops in 1,000 metric tons in Mozambique, 1961-1999. Source: FAO (2000a).



The main cash crops in order of export earnings in 1998 are: cotton lint (US$ 15 million), cashew nuts shelled ($10 million), sugar total raw equivalent (US$ 5.7 million), and tea (US$ 0.23 million) (see Figure 10). Cash crops are important for the family farm household income in some districts. In the last years of the colonial period, there were considerable increases in sugar cane, cashew, tea and tobacco production. Following independence, production levels plunged heavily as a result of factors such as the breakdown of the market and the destruction of the processing companies due to the return of the Portuguese settlers, and the disappearance of the colonial forced labor production (*chibalo*). The much slower production gains of the 1990s are an interesting contrast to the real increases of the staple crops.

Figure 10. Production of main cash/export crops in 1,000 metric tons in Mozambique, 1961-1999. Source: FAO (2000a).



Cotton has been and still is the main cash crop in northern Mozambique (Cabo Delgado, Niassa, Nampula and Zambézia Provinces). Production of seed cotton was 118,000 Mt in 1975, then fell to less than 33,000 Mt in 1985, and increased to 51,500 Mt in 1994 and

91,000 Mt in 1999. The harvested area shows about the same pattern, with a slower increase in the post-war period than the per hectare production. A program for rehabilitation of the cotton sector is part of the national planning policy. It is interesting that yield decreased in the drought years 1981-84 and 1986-87, but in the drought period 1991-92 the yield increased.

Sugar was produced by large cane companies (plantations), such as Sena Sugar Estates Ltd., Companhia Colonial do Buzi (Sofala Province), and the Sociedade Agrícola do Incomati (Maputo Province). Production reached its maximum in 1972 with 3.15 million Mt. All the companies were nationalized after independence. The total sugar production decreased to a minimum of 215,000 Mt in 1987 (to 1/14th of the 1972 level) and since then has hovered around a level of 200,000 to 350,000 Mt. The government and the African Development Fund have been planning the rehabilitation of the sugar sector since the beginning of the 1990s with massive foreign monetary aid.

In 1986, Mozambique ranked eight, after Kenya, Malawi, Tanzania, Zimbabwe, Rwanda, South Africa and Mauritius, among African tea producers (EIU 1996). The main production areas are the Zambézia hills and mountains close to the Malawi border. The country produced 19,000 Mt in 1973, then fell to a minimum of 13,500 Mt in 1975, and increased strongly until 1981 (22,190 Mt). It is currently on a level of about 15,000 Mt per year. The civil war was one of the most important reasons for the severe decline in production. In 1987, RENAMO destroyed the equipment of five tea-processing factories. The principal markets for tea are the United Kingdom and the USA.

Production of cashew nuts was 360,000 Mt in 1975 and declined almost to zero in 1984 (20,300 Mt). In an attempt to increase production levels, the government doubled producer prices for the crop. In late 1991 the government authorized the export of cashews in unprocessed form for the first time since 1976. But still, the cashew nut production remains quite low, about 50,000 Mt per year.[30]

Coconut and copra is mainly produced on plantations in the coastal belt of the Zambézia and Nampula Provinces. Coconut production varied in the period 1970 to 1999 between 410,000 to 450,000 Mt total production per year. Coconut is a popular crop for subsistence farmers who use the oil and other products in everyday life and for income.

Agricultural production by province according to national statistics

Data sources used in this section are the *Agricultural Survey of the Family Sector 1996* (MAP 1996), the *District Development Profiles* of the UN System in Mozambique (2000) and the *Agrarian Statistics 1996* (MAP 1997). The first two sources provide data for the family farm sector, for instance, on farming systems, yields and cropped area, auto-consumption and marketing, without a time series. The third provides information back to the year 1986 for the commercial sector, namely, the state, private, and cooperative sector, for instance, on crop and livestock production, commercialization and forestry. The family sector is not of importance in these statistics and consists of irregularities in terms of errors, either of total area harvested

[30] For a critical analysis about the failure of cashew rehabilitation by the IMF, see Hanlon (1996, 1995).

or total production.[31] The following paragraphs describe agricultural characteristics by province, starting in the northern part of the country.[32]

In **Cabo Delgado**, the mean size of the cultivated area[33] per household in the family sector is 2.28 ha or 0.62 ha per household member. In order of production, the main food crops are maize, cassava, millet, groundnut, beans and rice. Significant is that the majority of the food crops are auto-consumed, about 99% of the total rice production, 93% of cassava, 90% of millet, and 78% of maize production. Commercialized food crops are butter (wax) beans (100% of total production), followed by other beans (82%), maize (22%) and groundnut (15%). Cash crops are cotton and coconut, which are commercialized by 100% and 21%, respectively. Of interest is the market value for tobacco and sesame, although no cultivated area is reported in these statistics. Major crops in the commercial sector (MAP 1997) are rice, beans and cotton, millet and groundnut. The total production for the first three crops constantly decreased until 1992 and recovered to the 1986 level in the year 1996/97. Millet and groundnut production has been recorded since 1993/94.

In **Niassa**, the mean size of the cultivated area per household in the family sector is 2.37 ha, or 0.56 ha per household member. Important food and staple crops are maize, millet, beans, cassava, and groundnut. The majority of production is auto-consumed, about 98% of the total millet production, 98% of cassava, and approximately 80% of the maize production. Commercialized food crops are sweet potatoes (68 % of total production), followed by maize (about 29%) and beans (21%). Important cash crops are tobacco and cotton, which are commercialized by 160% and 99%, respectively (the 160% might be explained by tobacco import from the neighboring Malawi). Listed crops in the commercial sector (MAP 1997) are maize, beans and vegetables, rice and groundnut. The cultivated area for the first three crops constantly declined between the cropping seasons 1986/87 to 1995/96.

In **Nampula** Province, the mean size of the cultivated area per household in the family sector is 2.60 ha, or 0.64 ha per capita. Ordered by importance of total production, the main staple and food crops are cassava, beans, maize, groundnut, and rice. Almost the complete harvest of the following staple crops is auto-consumed: 95% of the total cassava production, 97% of millet, and 67% of maize. Each household consumes 66% of the groundnut production and 77% of all beans. Important cash crops are cashew, cotton and coconut, which are commercialized by 70%, 99% and 22%, respectively. The low commercialization rate of coconut and the limited commercialization of cashew may be a combination of the importance of these products in the daily household diet, and the absence of markets. The small production of tobacco is 100% commercialized. Recorded crops in the commercial sector (MAP 1997) are maize, beans (with a significant production peak from 1987/88 to 1993/94), vegetables, and groundnut. Millet and cassava production are reported in this province, too. Cotton is the leader of the cash crop production, followed by tobacco and sunflowers.

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[31] The calculated yields per hectare from this data vary too much and must be adjusted before they can be used in the analysis.

[32] For comparison with the water model chapter by Hellmuth et al. in this volume, the country was split into three Socioecological Regions: SER-A encompasses the northern districts Cabo Delgado, Niassa, Nampula, and Zambézia, and covers approximately 50% of the total land area, with 52% of the total population. SER-B encompasses Tete, Manica and Sofala Provinces, and covers about 29% of the total land area, with approximately 20% of the total population. SER-C is defined by the Provinces Inhambane, Gaza and Maputo, and covers about 21% of the total land area, with approximately 28% of the total population. SER-C also includes the capital city Maputo.

[33] Here, cultivated area includes annual crops, permanent culture, pastures and fallow ground. For comparison, pastures are not included in the data in the first paragraph after Table 1.

In **Zambézia**, the mean size of the cultivated area per household in the family sector is 2.19 ha, or 0.49 ha per household member. The main food crops, according to the order of mean planted area, are maize, cassava, millet, rice, beans, meixoeira[34] and groundnut.[35] As in most provinces, the main part of production is auto-consumed: about 76% of the total maize production, 100% of millet, almost 100% of meixoeira, 96% of cassava, 92% of rice and 82% of beans. The most important commercialized food crops are groundnut (45% commercialized), maize (23%), and sweet potatoes (13%). Important cash crops are cotton and cashew, of which 100% and 62%, respectively, are sold. Listed food crops in the commercial sector (MAP 1997) are rice, beans, cassava and since 1989/90 millet and groundnuts. Of importance for the commercial sector, which includes the state farm sector, is cotton, copra and tea production.

In **Nampula** the cultivated farm area with trees accounts for about 20% and the fallow ground for about 13% of the total area. Cabo Delgado's distribution is about 3% and 22%; Niassa's distribution is about 3% and 17%; Zambézia's distribution is about 27% and 10%. This indicates that there is more shifting cultivation in Niassa and Cabo Delgado. Characteristic for all four northern provinces is that beef production is almost non-existent in the family farm sector (MAP 1996). Therefore the amount of the household's total agricultural area devoted to pastures is almost 0%. In all four northern provinces, almost every household keeps chicken, followed by goats or ducks, and swine or ovine, with more importance on ducks in Nampula and Zambézia and on goats in Cabo Delgado and Niassa. Livestock is used for auto-consumption and for marketing purposes. Ranked by the number of sold heads, chicken are first, followed by goat, swine and ducks.

In **Tete**, the highest and most interior province of the central region, the family farm sector has a mean size of 2.10 ha of cultivated area per household, and 0.40 ha per capita. Manica, bordering Zimbabwe, has a mean cultivated area per household of 2.42 ha, or 0.42 ha per household head. Sofala has a mean cultivated area per household of 3.05 ha, or 0.57 ha per household head. The difference between the provinces is the amount of land that is fallow – 12% in Tete, 10% in Manica and 4% in Sofala. Sofala is the only reported province of the central region with a mean area of 0.74 ha under tree cultivation (that is about one-fourth of the total cultivated area); Manica has a mean area of 0.03 ha under pasture. In general, most of the farm area is used for annual crop cultivation.

Ordered by total production the main food and staple crops in **Tete** are maize, millet, meixoeira, and root vegetables such as potatoes, sweet potatoes and cassava. In addition, vegetables such as groundnut, onions, lettuce, tomatoes and garlic are grown. The auto-consumption rate is almost 100% for the majority of the food crops (especially cassava, millet, and meixoeira). Income is generated from selling groundnut, beans and maize (53% of the total production, 19% of all bean varieties and about 12% of maize production) and sugar

[34] Meixoeira: African tree with edible seeds.

[35] The order of importance of crops can be different when they are based on the mean planted area or on total production. But for all four provinces, the ranking does not really change based on mean planted area by household or total production. Also, the ranking is almost the same, when looking at the order by percentage of households which plant these crops. For the Province Zambézia for example, the order for total production in metric tons would be: maize, cassava, rice, millet, meixoeira, beans and groundnut, instead of maize, cassava, millet, rice, beans, meixoeira and groundnut. This result is based on the following factors: a) the observable and evident importance of these crops for food consumption – the "typical" diet composition; b) the quite low hectare productivity, which means that the differences between the crops are small; and c) the "absence" of consumer goods markets, which means that farmers are forced to produce their own food.

cane.[36] Tobacco and cotton are the two typical cash crops, but are not of significant importance in the family farm sector. Major crops in the commercial sector (MAP 1997) are maize, millet, groundnut, beans, and vegetables. According to the production data for the commercial sector, only maize is of importance. Irrigation is recorded only for vegetable production and in small areas for rice production.

In **Manica** the main food crops in order of importance are maize, millet, meixoeira, beans, sweet potatoes, cassava and groundnut. The typical food and staple crops have a high auto-consumption rate. Households consume roughly 87% of the total maize production, 99% of millet, 92% of cassava, and between 75% and 88% of beans. Besides the commercialization of the mentioned food crops of between 2% and 25% of the total production, cotton (100%) and sesame (42%) are of importance for income generation. The MAP (1997) database also records maize, millet, groundnuts, sunflowers, cotton, and citrus fruits.

In **Sofala** Province, in order of importance of total production and area under cultivation, the main staple and food crops are maize, millet, cassava, rice, all sorts of beans, meixoeira and groundnuts. Typical cash crops are cashew, coconut, sesame, cotton and tobacco. The majority of the people in Sofala Province live along one major road (the Beira corridor) and in Beira, the second largest city of Mozambique. The auto-consumption rates in the family farm sector are as high as in other provinces. The households consume about 97% of the total millet production, 96% of meixoeira, 94% of cassava and rice, and 87% of maize. Family farms sell about 30% of the groundnut production, 36% of the cashew, about 45% of the wax beans, 77% of the tobacco production if existent, and more or less the total cotton production. Recorded food and staple crops in the commercial sector (MAP 1997) are maize, millet, vegetables, beans, cassava, and groundnut, and main cash crops are cotton, sugar cane, and of less importance sunflowers and tobacco.[37]

Chicken, goats and ducks, in order of importance, are the main source of livestock in the family farm sector in the central provinces for both auto-consumption and marketing. Cattle are common in all three provinces, but are most common in Manica where livestock production has a long tradition.[38] Still, present livestock production is below pre-independence levels. The major loss of livestock was reached by end of the civil war in 1993. Several drought years and especially the 1992/93 drought reduced the already war-affected herds. According to MAP (1997), meat production counted by head of animals is big in the family farm sector. Cattle are not only a source of protein, but also particularly important as draft power and transport, and to provide manure for fertilizer.

In the **Gaza** Province the mean size of the cultivated area per household is 3.80 ha, or 0.87 ha per capita. Inhambane, with its main road connecting to Maputo City to the north, has a mean cultivated area per household of 2.66 ha, and 0.46 ha per household member. Maputo Province, the smallest and most urbanized province, has a mean farm size per household of 2.55 ha, and 0.46 ha per household head. Maputo Province has the lowest proportion of land under fallow, which is about 2% of the total area. Inhambane, with quite good infrastructure,

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[36] Many small-scale farmers (family sector) plant sugar cane along small rivers, the more moist areas of their land, and it is part of their daily diet. Quite often sugar cane is sold at the local market (just three sticks) to generate additional farm income. In this context sugar cane is not the classical plantation cash crop.

[37] During the Portuguese colonial period the important sugar cane and cotton plantations and factories were located in Sofala Province. Many of the factories were destroyed during the civil war and former plantation areas are now occupied by small-scale farmers.

[38] Two-thirds of Mozambique (most of SER A and SER B) are affected by the Tse Tse fly.

has about 5% of the area under fallow. Gaza has the highest rate of fallow land (12%) in the southern region. Even though the region is more suitable to cattle production, only small areas in the family sector area are classified as pastures: 2% in Gaza, 3% in Inhambane, and 0% in Maputo Province. The majority of the farm area is devoted to the annual cropping system (18%), tree farming (4%) and pastures (18%).

In **Inhambane**, the main food and staple crops, ranked by total production, are maize, beans, groundnut, root vegetables such as cassava, potatoes and sweet potatoes, millet, rice, sesame and meixoeira. Almost the total harvest of the following staple crops is auto-consumed: 92% of total maize, 91% of beans, 82% of cassava, 99% of millet and 93% of groundnut production. Of importance for household income is the sale of sweet potatoes (more or less the complete harvest) and some vegetables, such as onions, tomatoes, cabbage, lettuce, garlic, peri-peri, pepper, pumpkin and carrots. Important classic cash crops for a few farmers are cotton (Govuro and Homoine district), cashew and coconut along the coast. Also to a lesser extent tobacco and sunflowers are reported. Major crops in the commercial sector (MAP 1997) are maize, cassava, groundnut, beans, vegetables and rice, and cash crops such as copra and sunflowers.

In **Gaza** the main food crops in order of importance are maize, cassava, beans, and groundnut. For a small number of farmers, rice is a significant staple crop, which is marketed by 30%. The other typical food and staple crops have the same high auto-consumption rates as the other provinces. Almost 100% of the total millet production, 91% of cassava, 79% of maize, 20% of sweet potatoes, and about 50% and 92% of the beans (depending on the variety) are consumed by the households. Besides the commercialization of the mentioned food crops between 0% and 50% of the total production, cashew and copra are of importance for income generation. Vegetables are mostly grown in the cool season. Reported constraints are irregularity in rainfalls, pests, lack of seeds and lack of capital (UN System in Mozambique 2000). The MAP (1997) database records maize, groundnut, vegetables, beans, onions, industrial tomatoes, cassava, and cotton.

In **Maputo** Province, in order of total production and area under cultivation, the main staple and food crops are maize, beans, groundnut, cassava and sweet potatoes. Vegetables include pumpkin, lettuce, garlic, onion, cabbage, cucumber, okra and tomatoes. Even in Maputo Province, despite its proximity to the nation’s capital, auto-consumption rates in the family sector are high: 87% of the total maize production, 100% of groundnut and beans, 75% of sweet potatoes, and 63% of cashew. The small remaining amounts are sold on regional markets. Rice, sunflower seed, sugar cane, bananas and vegetables are grown by the family sector as cash crops. Recorded food and staple crops in the commercial sector (MAP 1997) are maize, rice, cassava, vegetables, beans, groundnut, water lemons, and sugar cane. Irrigation and fertilizers are used in the commercial farm sector, while the family sector uses traditional methods such as manure, inter-cropping, and crop rotation.

The main domestic animals for household consumption are chicken, goats, ducks, swine and rabbits, in various order depending on the district (except chicken and goats, which always rank first and second). Goats, pigs, cattle and chicken are important for marketing. Cattle are common and used for meat and as draft and transport animals. As mentioned at the beginning of the section, the main factor favoring the development of livestock farming is the existence of large pastures, suitable climate and a cattle-ranging tradition. Current differences in livestock sizes by districts are the result of the civil war combined with drought years. Reported constraints on livestock production are animal diseases, lack of extension services and shortage of money to buy stock (UN System in Mozambique 2000).

HIV/AIDS and Agricultural Development: General Discussion

Looking at the agricultural transformation process in Africa, Richards (1985) says that farmers have had neither the time nor inclination to homogenize their land for machines or chemical-intensive plant ideotypes. Furthermore, Africa has suffered more from labor shortages than lack of land. Mitchell et al. (1997) observe that agricultural science, which is based on an one-at-a-time isolation of significant variables, has found it hard to conceive ways of working with the huge diversity of crops and land types as is found in the African "subsistence agriculture." Instead, development efforts have favored the transfer of technology, the introduction of mono-cropping systems, and an "under-investment" in locally innovative agricultural research.

Barnett et al. (1995) and the FAO report (1995) elucidate that farming systems vary in the vulnerability to the challenge of HIV/AIDS. Studies in West African grain cropping systems (Richards 1986) and Eastern African banana/maize/root crop farming systems (Barnett and Blaikie 1992; Barnett et al. 1995) show that in areas with a large HIV infected population, the Eastern African systems are less affected by the disease. The West Africa rainfed farming systems as described by Richards (1986) tend to abandon upland rice production and switch to small survival patches of "garden" and dry-season wetland crops, such as sweet potatoes. The East African systems seem to be more flexible to the loss of labor of family members who have to nurse a household member with an AIDS-related illness.

The greatest impact is not felt by the weak. "HIV/AIDS, in a way, 'selects' for the strong – for the professional classes, for household breadwinners. This is a reflection of the strong connection between mobility and wealth generation in African society. HIV/AIDS is, in effect, a network disease, especially associated with the urban notes and major transport arteries." (Richards 1999: 98)

In economic terms, households nursing members with AIDS are affected in various ways – often scarce reserves of rural capital are depleted. For example, households of post-AIDS survivors have to struggle to survive with cattle and other assets gone. Often only the land remains, especially in areas with customary tenure system (Rugalema 1998).

HIV/AIDS may have several effects on agricultural production, which is dependent upon the social, socioeconomic, and farming systems, as reported in several studies.

1) The situation is worsened by the fact that HIV/AIDS is transmitted heterosexually in Africa (FAO 1995; World Bank 1999). The probability that both parents die is very high. According to the results of the IIASA Population-Development-Environment case studies in Botswana (Sanderson et al. 2001a), Namibia (Sanderson et al. 2001b), and Mozambique (Wils et al. 2001) the ratio of the population group aged 40-49 to children will stay more or less constant, even in the behavioral change scenario (i.e., reduction of HIV transmission). However, the overall size of the rural population will decrease, and the remaining population will consist of children and elderly.

2) HIV/AIDS may deplete the scarce monetary resources of affected households through payments for medical treatment (traditional and/or conventional treatment), funeral costs and special food (mourning customs). Some of those resources would have been used for purchasing agricultural input (agro-technical improvements, seeds, occasional extra labor, family assets such as livestock, etc.).

3) The decrease in labor force due to AIDS deaths or the loss of time incurred by nursing sick HIV-positive family members (reduced labor quantity and labor quality) may result in: changes in the cropping system; reduction of the cultivated area; minimal soil conservation measures; decreases in productivity; abandonment of cash-crop

production in favor of food or subsistence crops; change to labor-saving time crops which could result in a strong decrease of vegetable cultivation; and less intensive livestock production, which can result in a less varied and less nutritious diet. Other impacts can be the reduction in the ability to control pest diseases; the delay in farming operations such as tillage, planting and weeding; and the loss of agricultural knowledge and management skills. It can be assumed that the effects of labor loss due to AIDS deaths are similar to labor loss due to male rural out-migration (Prommer 1998). And, as is mentioned in the FAO report (1995), the transmission of acquired skills and knowledge will be affected by both, within an age cohort and from generation to generation.

4) In rural regions, where there is a high risk of HIV/AIDS and where the land tenure reform is pursued rapidly and aggressively, the number of landless households might grow.

5) Traditionally, the extended family network has developed successful coping mechanisms for emergency situations, such as natural disasters. Simplified, the system is based largely on the exchange of labor in the farm, family, and community units, as well as in the form of gifts, food and monetary help. But we have to bear in mind that these systems have their limits and can collapse.

6) As a result of AIDS deaths in the rural households, children can be forced to increase their labor contribution. This can result in higher school drop out rates or even no school attendance at all, especially for female children. HIV/AIDS has already worsened the indicators of economic and human development (i.e., Human Development Index). It has increased poverty by depleting the middle income-producing generation in households. It has increased poverty in communities and caused changes in the social household structure (World Bank 1999).

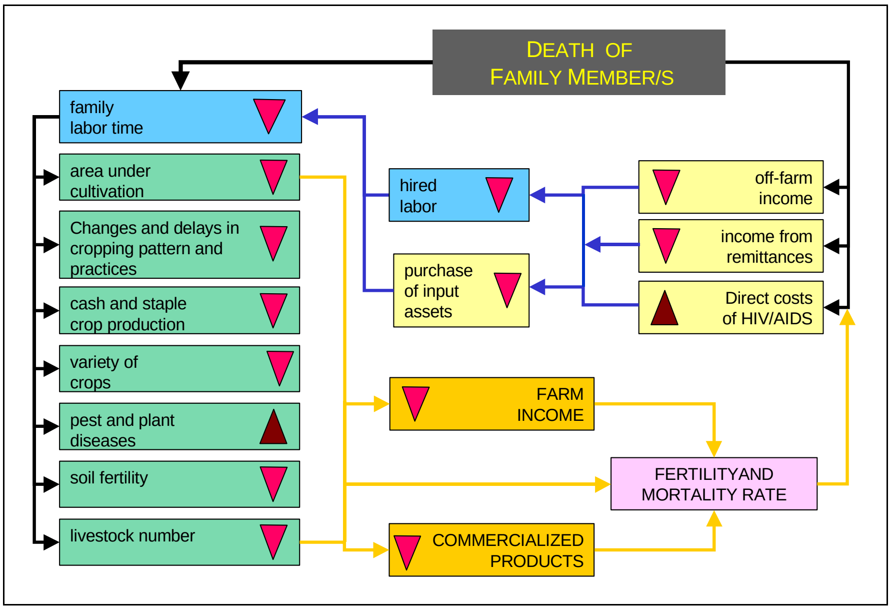
7) We know from other more severely hit countries that many children will be orphaned. What happens to these young orphans? It is likely that the social relocation follows matrilinear lines, which often means being cared for by the grandmother (FAO 1995). Does this lead to an increase of relocated orphans to households headed by middle age or older women? Or even worse, child-headed households?

8) The impacts for widows might be different than for widowers. Women can lose access to land and assets, labor, inputs, credit, and support services (Baier 1997). Legal frameworks are not sufficient by reason of existing communal laws and traditions, which are still imposed in most rural areas. For example, the brother-in-law might “inherit” the widow; the brother-in-law might take over the livestock, leaving the widow with no possibility to support her family; the widow might be forced to move back to her parents place; and many others.

9) How will the international donor organizations react to the impacts of HIV/AIDS affected households? As De Waal (1997) notes, the alliance between humanitarian organizations and “neo-patrimonial” African regimes is as unhealthy for democracy and human rights as it is for agricultural development. The challenge to guarantee sustainable development, good governance and human rights will, therefore, be dependent on the international community and the willingness of governments to deal with this issue on all levels.

Figure 11 shows a simplified diagram of the possible impacts of HIV/AIDS on farming systems, presented as a descending circle. A farming system dependent upon family labor may face serious decreases in production because of such factors as direct loss of labor force, decreasing area planted and harvested, and direct costs of HIV/AIDS.

Figure 11. Impact of HIV/AIDS on agriculture, represented as a vicious cycle.



Conclusions

The evidence of the spread of HIV/AIDS in rural areas has often been overlooked because of poor data, irregular spread of the disease, and assumed lower prevalence rates than in urban areas. It is important to note that countries that rely heavily on agriculture, such as Mozambique, may lose their knowledge of soil conservation, erosion control, and farm, crop, and livestock management skills – so-called brain drain – because of AIDS deaths of the most active population group. Studies on the loss of vertical knowledge transfer should be conducted in order to better understand the impacts of HIV/AIDS on household compensation strategies.

We can assume that the effects caused by changes in cropping pattern will be similar to those caused by rural out-migration (Prommer 1998) with one important difference – the additional loss of remittances due to AIDS deaths. This will be worsened by increasing HIV incidence rates for African women, with women under 25 representing the fastest growing group. The highest rates of rural out-migration are in the age groups 20 to 40 years, which leads to an erosion of the male labor force. The labor loss is higher in the southern provinces due to traditional labor migration movements to South Africa and other African countries. Both factors combined may lead to substantial labor losses in the non-mechanized and household labor intensive family farm sector (where the majority of the population is active), especially in the poor and barely literate families.

Production and yields have increased considerably since the Peace Agreement in 1992. The family farm sector is still dependent on household labor and labor exchange. The households still depend on their own production and have limited purchasing power, which becomes visible when we look at the auto-consumption rates of the major staple crops and so-called cash crops. Mechanization and the input of a modern means of production, such as fertilizers and herbicides, are rare (FAO 2000a). It cannot be expected that the situation will improve because of the financial burden of direct HIV-related costs for the households.

A recent vulnerability assessment study on food and nutritional insecurity for 1997/98 (Republic of Mozambique 1998a) suggests that a large number of districts are vulnerable to both transitory and chronic food insecurity.[39] The most food-vulnerable households have other sources of income such as petty trading (the most important one), ganho-ganho (labor exchange for food or cash), and the sale of cash crops. This means that they are dependent upon their own production and low paid, insecure job opportunities. The food-secure households have a more diversified income and production strategy, which includes livestock production, fishing, and formal employment (Republic of Mozambique 1996, 1998a, 1998b; Instituto Nacional de Estatística 1998; Tschirley and Weber 1994).

What does this mean for Mozambique, which, according to the official statistics, is not as seriously hit by the HIV/AIDS pandemic as the other southern African countries? According to Wils et al. (2001), the HIV/AIDS epidemic will not lead to an economic catastrophe. These overall national results do not provide insight in the existing production system. Using the descriptive analysis of the existing data, we can assume that Mozambique will have to formulate agricultural development plans and implement strategies to minimize the negative impacts of the disease to a particular part of the population. Future strategies to reduce the annual number of new infections should continue to be one of the core issues. Detailed studies on how households can cope with the loss of the most active population group – namely the adults, who do the majority of the agricultural work – could be helpful. The absolute number of possible affected households may be considerable because of the population size. The author proposes to provide a framework in which the farmers can diversify their production (risk-reducing strategy for economic and natural crisis periods). This includes multi-cropping systems based on traditional (but improved) varieties, and the knowledge to 1) reduce seasonal labor peaks, 2) lower the risk of soil depletion and erosion, and 3) decrease the risk of total harvest loss, for instance, due to irregular rainfall (flood or drought). Further, access to markets, crop storage, seed access, health centers, schools, and other infrastructure are of major importance.

In the discussion on poverty and HIV/AIDS we have to recognize that this is a bi-causal relationship, which needs to be understood by those involved in policy and program development. The evidence reveals the interdependence of the social, economic and political systems, and it is precisely the capacity to function normally that is being undermined by the epidemic. In this context, principles for action have to include the eradication of inequalities, including women in decision-making and mitigation processes, a good judiciary, and civil society organizations. In the reported and observed responses by communities and families, the first line of action was to create volunteer structures to offer assistance. These groups are promoting other needed changes as well, such as increasing the acceptance of women and young people in the power structure, opening and strengthening civil society, and expanding the acceptance of development programs in agriculture, education, and health. These groups need support and a clear legal and flexible framework within which to work according to their specific needs, considering that the epidemic affects each village in a different way. Furthermore, the actions taken by one single country are less effective than actions taken jointly by several countries. Cross-learning is necessary to develop and implant policy, programs, and a regional supply of technical expertise. We have to keep in mind that the

[39] The southern provinces are most affected, especially all Gaza districts (food availability below 6 months), followed by the districts in the interior, Inhambane, Maputo Province, Sofala, and the districts south of the Zambezi River in Tete Province (food availability mostly below 9 months, with a few districts below 6 months). All districts north of the Zambezi with the exception of Mutarara and Chinde districts, Manica Province, and the southern coastal districts of Inhambane are listed with a food availability over 12 months, and a few between 9 and 12 months (Republic of Mozambique 1998a:19ff).

dimension of the HIV/AIDS pandemic in Africa, from a psychosocial to a socioeconomic standpoint, can also be a threat to international security (UN Security Council) and requires a rethinking of the position of the western countries. Desmond Cohen, former Director, now Senior Advisor of the HIV and Health Development Programme of the UNDP, said: “While past efforts have largely focused on predicting what might happen, the world and the epidemic have moved on and reality is now only too often worse than any prior predictions” **(**Cohen 1999:1).

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THE MOZAMBIQUE WATER MODEL

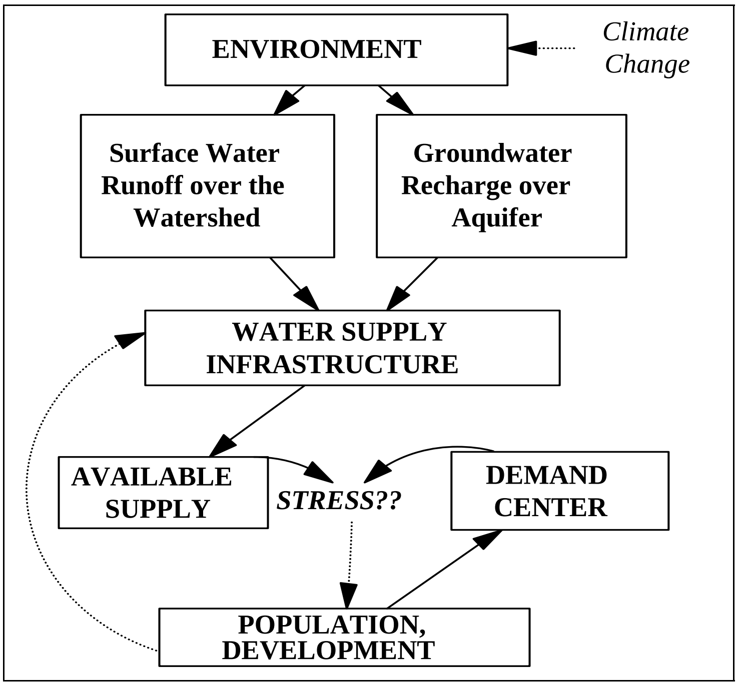
Molly E. Hellmuth, David N. Yates, and Kenneth M. Strzepek

Introduction

The water model is composed of three main parts: a water balance model, a water supply model and a water requirement model. The water balance model is a two-layer model of surface and ground water processes. This model is an extension of the rainfall-runoff water balance model CliRun developed by Kaczmarek (1993), and modified by Yates (1996) to include a potential evapotranspiration routine. The water supply model represents the water available due to infrastructure such as reservoirs, pipelines and groundwater pumps. Finally, the water requirement model computes the water demands of the major water supply consumers: industry, agriculture, institutions, and households. These three model components are described in this chapter.

Figure 1 shows a schematic of the water model. The water model breaks the region of interest down into the pertinent watersheds that contribute water to the surface and groundwater supply. The water that is available to the consumers is the surface water runoff that is captured by surface infrastructure or the groundwater recharge that allows for sustainable abstraction. This water is then available as supply for the end users, or demand centers.

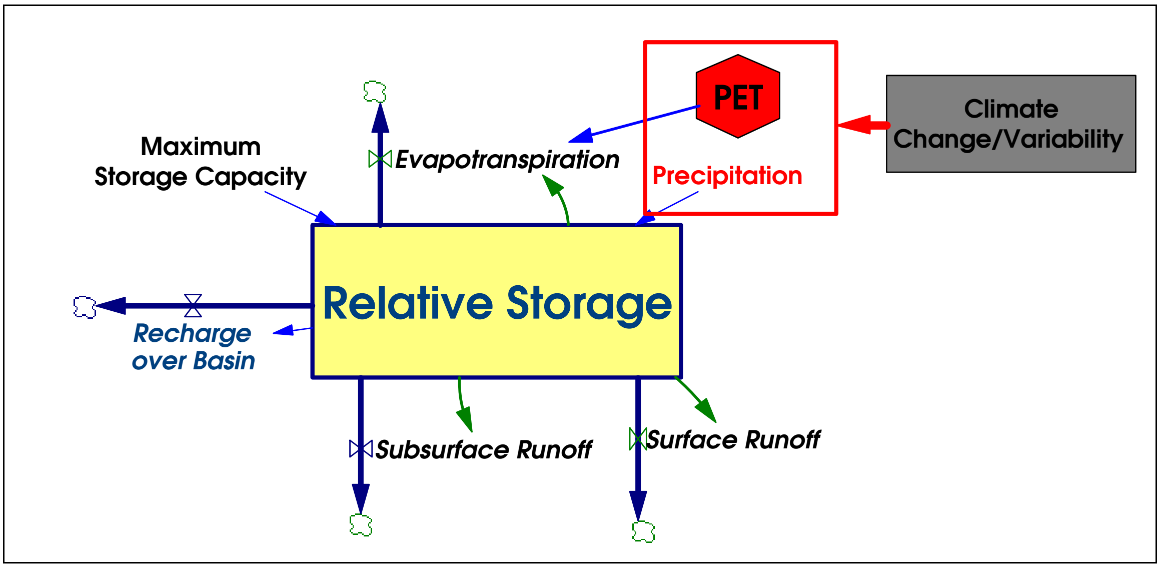
Figure 1. Water model schematic.



The Water Balance Model

The model schematic of the surface water component can be seen in Figure 2. The water balance model creates a mass balance within the soil moisture zone, taking into account precipitation, runoff, groundwater recharge and actual evapotranspiration, while using PET to derive the extraction of water from the soil moisture. There are three calibration parameters, α, ε, and λ, and five exogenous parameters: temperature, precipitation, vapor pressure, latitude and soil moisture capacity. The model uses an "average day" value of precipitation and temperature for each month of the historic series. This captures the non-linear dynamics of the evapotranspiration processes, which are storage dependent and cannot be accurately approximated at a monthly time scale.

Figure 2. Water balance model schematic.



A mass balance is calculated in the soil moisture zone, which is represented by the following equation:

$$z(t+1) = [P(t) - R_s(t) - R_{ss}(t) - ET(t) - RD(t)] \div S_{max} \quad (1)$$

where ET = evapotranspiration (length/time)

P = precipitation (length/time)

R_s = surface runoff (length/time)

R_{ss} = subsurface runoff (length/time)

RD = groundwater recharge depth (length/time)

S_{max} = soil moisture capacity, (length)

z = relative storage ($0 < z < 1$), (dimensionless)

Evapotranspiration is a function of the PET and the relative storage (z). The PET is calculated by the Priestly-Taylor method (see Appendix A). This method was chosen because of its simplicity and the evidence supporting such an empirical relationship on a regional basis (Yates and Strzepek 1994). The Priestly-Taylor method uses regional data series of temperature, relative humidity, latitude, and sunshine hours to compute the PET. A non-linear relationship is used in this model to describe evapotranspiration (Kaczmarek 1993):

$$ET(t) = PET(t)*(5z(t)-2z(t)^2)/3 \quad (2)$$

The surface runoff is described in terms of the relative storage state, z, and the precipitation, P. As the relative storage becomes very small, the surface runoff term should approach zero:

$$R_s(t) = z(t)^{\varepsilon} * P(t) \quad (3)$$

where epsilon, ε, is a dimensionless power term used to calibrate the basin.

The subsurface runoff is a function of the relative storage multiplied by a coefficient alpha, α, and raised to a coefficient gamma, γ. As gamma decreases, the subsurface runoff decreases relative to the soil moisture, indicating a decrease in the retention capacity of the soil. Gamma is assumed to be 2 for this exercise. The coefficient alpha is used in the calibration process.

$$R_{ss}(t) = \alpha z(t)^{\gamma} \quad (4)$$

The soil moisture capacity, S_{max}, defines a particular catchment's maximum storage in terms of depth. The relative storage times the catchment's area and S_{max} gives the volume of water stored for the current storage period. This information is taken from the USGS gridded half-degree by half-degree soil moisture database (Dunne and Willmott 1996).

The total runoff, R, for each time step is the sum of the three runoff components:

$$R(t) = R_{ss}(t) + R_s(t) \quad (5)$$

The groundwater recharge depth (RD) is a function of the relative storage multiplied by a coefficient lambda, λ.

$$RD(t) = \lambda z(t) \quad (6)$$

The conceptualized groundwater model incorporates a groundwater recharge component that feeds into a groundwater reservoir for human extraction. There is one calibration parameter, λ. Figure 3 depicts the groundwater subsystem.

The groundwater in this model is only modeled in cases where the sustainable yield is known and it constitutes an important source of water, relatively speaking. The volume of recharge over the Aquifer (RA) is dependent upon the areal extent of the aquifer and the recharge depth (RD).

$$RA(t) = \text{Aquifer extent}(t)*RD(t) \quad (7)$$

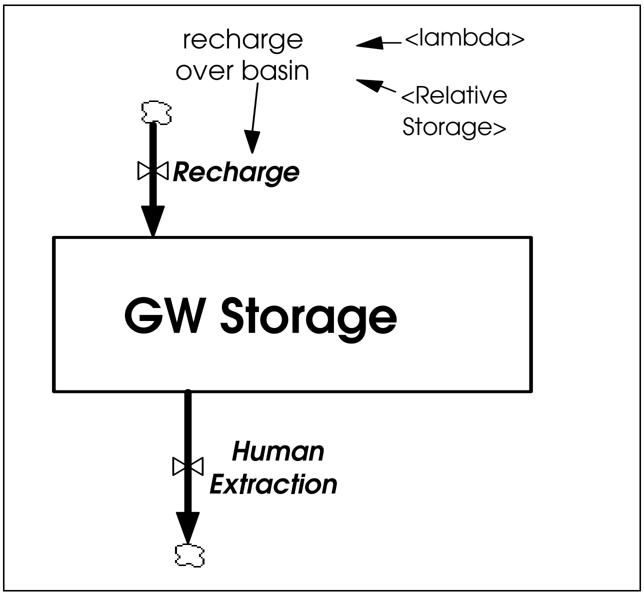
In this model, the sustainable yield is the only allowable abstraction, in order to prevent groundwater mining. Thus, it is assumed to be at steady state, so long as human extraction does not exceed recharge. The only inflows and outflows from the system are the recharge and the human extraction. Then, the groundwater storage (GS) is dependent on the human extraction rate (Hext) and the recharge over the aquifer:

$$GS(t) = RA(t) - Hext(t) \quad (8)$$

The sustainable yield is equal to the rate of recharge. Since the model assumes that groundwater can be used only at a sustainable rate:

$$Hext(t) = RA(t) \quad (9)$$

Figure 3. Groundwater schematic.



The calibration parameters α, ε, and λ, are used to parameterize the runoff and recharge which is produced in each basin after a rainfall event. The calibration of any model is dependent on what actual data exists, the quality of the data, and the scale of the model. For well-monitored catchments, the rainfall-runoff/recharge processes can be calibrated using matching time series data of historic monthly rainfall, runoff, recharge, temperature and actual vapor pressure. If the data is not available, other less data-intensive methods need to be devised. In all cases, the objective is to accurately capture the amount of runoff/recharge that occurs due to a rainfall event and antecedent soil moisture conditions.

The calibration parameters affect surface runoff, subsurface runoff, and groundwater recharge, as previously described. The objectives are to 1) match the mean annual runoff coefficient for the basin, and 2) match the average annual groundwater recharge for the basin.

In Mozambique, using the ARC as a proxy for runoff is necessary because there are not sufficient historical time series data to calibrate the model to actual runoff events. Determining the ARC values requires knowledge of the basin runoff and precipitation.[40] The first two-thirds of the historical precipitation, temperature and vapor pressure record were used to calibrate the model, while the last third of the record was used to validate the calibration.

[40] Several sources were used to determine the mean annual runoff of the Mozambiquan watersheds: the GRDC global runoff map (http://www.grdc.sr.unh.edu), the Oak Ridge National Laboratory Distributed Active Archive Center (http://www.rivdis.sr.unh.edu/maps/afr/), and data from the "Country Situation Report, Vol. 1" (Consultec 1998). The latter data source is probably the most accurate of the three sources presented here, although these values do not include the decade of drought in the 1980s. The Links gridded half degree by half-degree dataset of precipitation was used to derive historical 95-year monthly precipitation series for each basin (see Appendix C).

The Supply Model

This section describes the methodology used to model the surface water supply. The dynamics of reservoir modeling are similar to the water balance technique described above, whereby a mass balance of water is computed at each time step using the reservoir as the control volume. The mass balance of any reservoir is dependent on the particular storage characteristics, the inflows, and the outflows. The inflows to the system are precipitation over the surface and runoff from the basins. The main outflows in the system are evaporation, demands, and excess releases. The reservoir has the following mass balance equation:

$$S(t+1) = I(t) - O(t) - E(t) - ER(t) \qquad (10)$$

where S = supply reservoir, m^3

I = inflow, m^3/mo

O = outflow, m^3/mo

E = evaporation, m^3/mo

ER = excess releases, m^3/mo

Evaporation losses are computed by the following equation:

$$E(t) = A(t) * ec(t) \qquad (11)$$

where A(m^2) represents the surface area of the dam, which is derived from volume to surface area reservoir curves. The evaporation coefficient, ec, is computed by the Priestly-Taylor equation (see Appendix A).

Excess releases occur when the reservoir is at maximum capacity level.

$$ER(t) = S(t) - \text{Maximum Capacity} \qquad (12)$$

If all of the runoff over a watershed produced from a rainfall event ends up in a specific water supply reservoir, then the inflow to the reservoir is equal to the runoff produced from the rainfall event. This is the case for the Gaborone case study model, which models the infrastructure specific to the city. However, in the macro region model, whereby some watersheds have little or no infrastructure, the water that does enter a reservoir is distributed to a virtual reservoir as Inflow (I), by the following equation:

$$I(t) = S_B(t) * T_{BR}(t) \qquad (13)$$

where T is the percentage of the basin runoff, which is transferred from a particular basin to a storage reservoir, based on the existing infrastructure. Sometimes the runoff from a particular basin can be distributed to several different reservoirs. The outflow from the reservoir depends on system water requirements (WR) and transfers (T) from the reservoir rule curves.

$$O(t) = WR(t) + T(t) \qquad (14)$$

The Water Requirement Model

The water requirements of four sectors were evaluated: domestic, industrial, commercial and irrigated agriculture. Water consumption in each of these sectors is driven by economic and/or population changes. Total water requirements (WR) are computed for each “demand” center as follows:

$$WR(t) = WR_D(t) + WR_I(t) + WR_C(t) + WR_A(t) \qquad (15)$$

where WR_D = domestic requirements

WR_I = industrial

WR_A = irrigated agriculture requirements

The domestic demands are driven by changes in per capita income and urban and rural population size. Domestic demands have a maximum water use (WU_{MAX}) level, which varies by urban and rural consumers. The total domestic water requirements are computed as follows:

$$WR_D(t) = (P_R(t) * WU_R(t) + P_U(t) * WU_U(t))/(1-L_S(t)) \quad (16)$$

such that $WU_R <= WU_{R, MAX}$ and $WU_U <= WU_{U, MAX}$

P_R = rural population

P_U = urban population

L_S = system losses

WU_R = rural water use rate

WU_U = urban water use rate

The rural and urban populations are computed by the population model (IIASA 2001). The initial water use rates are taken from data, and change over time dependent upon the GDP per capita output from the economic model (IIASA 2001). For example:

$$WU_R(t+1) = GDP/cap(t) * WU_R(t) + WU_R(t) \quad (17)$$

$$WU_U(t+1) = GDP/cap(t) * WU_U(t) + WU_U(t) \quad (18)$$

The projection of each of the consumers involves making assumptions about the loss rates. System losses, L_S , include losses at the source and losses during consumption. These losses are applied to the domestic and IEI demands, as follows:

$$\text{Total Demand}(t) = \frac{\text{demand excluding losses}(t) * 100}{(100 - \%\ \text{loss})} \quad (19)$$

The industrial water requirements (WR_I) include major and minor water demands presented in a study based on Maputo (DHV Consultants and Consultec 1995). The industrial water requirements are computed as follows:

$$WR_I(t+1) = (WR_I(t) + AG_I(t) * WR_I(t))/(1-L_S(t)) * Eff_{IEI}(t) \quad (20)$$

AG_I = annual growth in industrial activity

L_S = system losses

Eff_{IEI} = efficiency, percent

The efficiency variable allows for changes in the assumption of technologies being used.

Irrigated agricultural water requirements (WR_A) change dependent upon the month. According to the FAO (1997) the crop season is from December to March/April. The irrigation season was spread from December through April for this study. In addition, irrigated agricultural water requirements may become more efficient in the future, and some of the water used to irrigate the crops is not consumed and is returned to the system. The amount of water actually consumed will then be:

$$WR_A = Ha * UR_A * (1- RF) * Eff_A \quad (21)$$

Ha = hectares under irrigation

UR_A = monthly agricultural water use rate

RF = return flows, (%)

Eff_A = irrigated agricultural efficiency, (%)

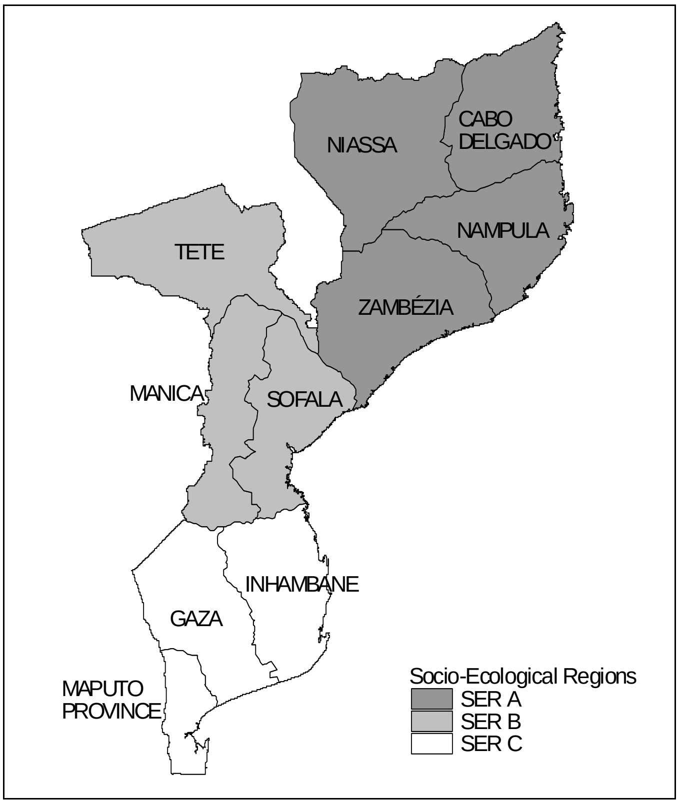
Finally, the commercial water requirements are driven by changes in the annual growth in the commercial sector (AG_c).

$$WR_C(t+1) = WR_C(t) * AG_C(t) + WR_C(t) \qquad (22)$$

Climate and Relative Soil Moisture in the Three SERs

The natural resources and geography of Mozambique varies greatly, and for the purposes of this study, Mozambique has been broken into three main socioecological regions (see Figure 4). These regions were derived based on the existing administrative, demographic and hydrologic characteristics of the country. The SERs represent an aggregation of the ten administrative boundaries, which are superimposed by the SERs in Figure 4.

Figure 4. The socioecological regions and administrative regions.

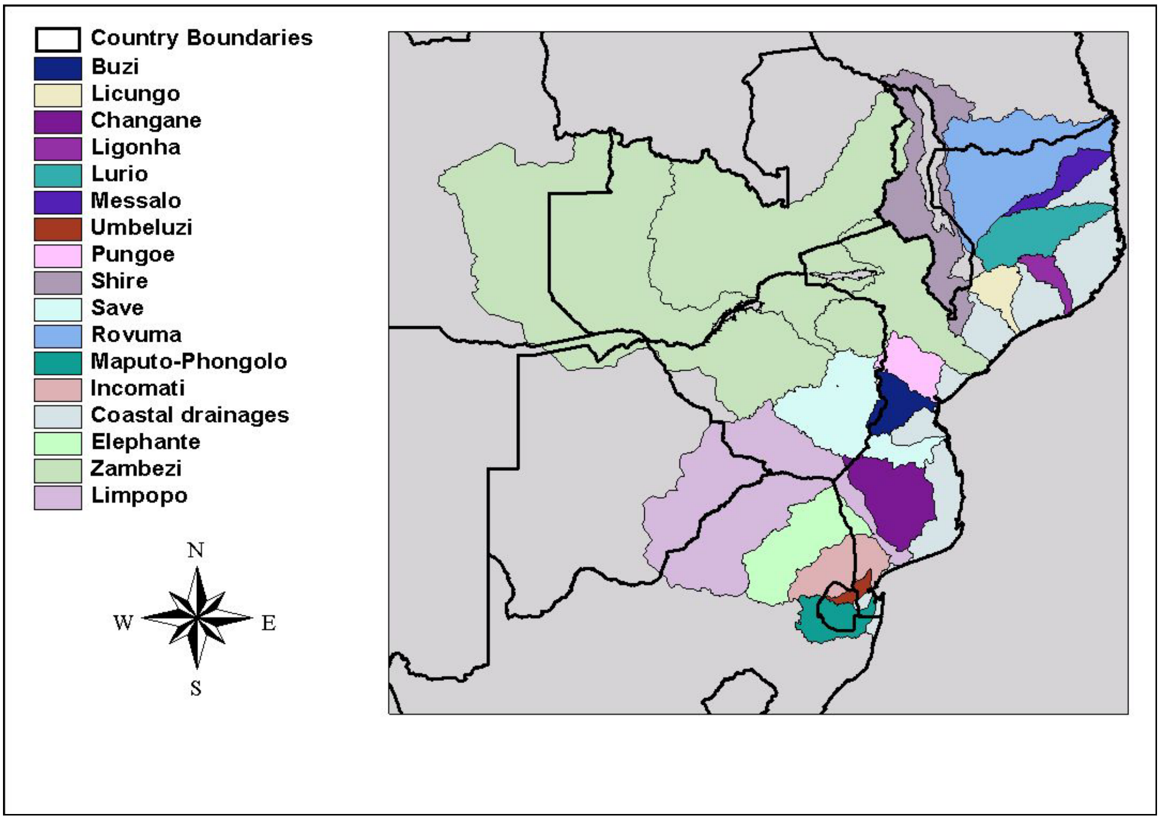


SER A encompasses the northern districts Cabo Delgado, Niassa, Nampula, and Zambézia. SER A covers an approximate area of 398,000 km^2, or about 50% of the total land area of Mozambique. This region contains 52% of the total population of Mozambique and produces the majority of the country's agricultural output. SER B encompasses the Tete, Manica and Sofala administrative districts, covering about 230,000 km^2, or about 29% of the area of Mozambique. This macro region contains approximately 20% of the population.

Finally, SER C is defined by districts Inhambane, Gaza and Maputo. This region covers an approximate area of 170,000 km^2, or about 21% of the total land area of Mozambique. Approximately 28% of the population lives in SER C, which contains the capital city, Maputo. The water resources of the three SERs are described in detail below.

The IIASA water resource supply model estimates water availability for each of the SERs by application of the IIASA PDE Model (IIASA 2001). This model forecasts 20 years into the future. Fifty-two major hydrologic basins and coastal drainages were delimited for analysis of Mozambique's potential and existing water resources.[41] These macro basins were determined based on the river basins and administrative boundaries, and are shown in Figure 5 (FAO 1997; Verheust and Johnson 1998). For each basin, the annual runoff coefficient was determined and used to calibrate the water model. This section describes the climate characteristics of the basins, and future scenarios for soil moisture variability without and with climate change.

Figure 5. Determined macro water basins.



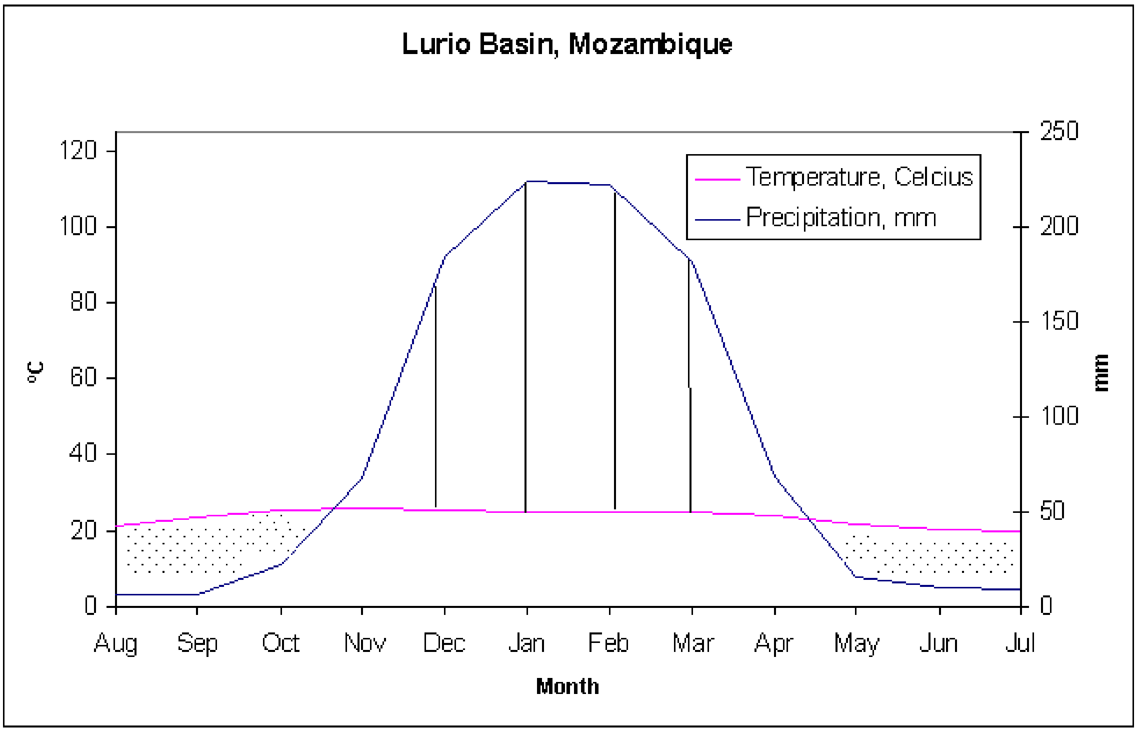
SER A – Northern Mozambique

In general, the northern region has higher temperatures, which vary from the coast to the inland. The mean annual temperature averages 25.5°C per annum in the coastal lowlands; however, moving into the northern uplands, temperatures drop due to elevation (i.e., Lichinga averages 18°C). The majority of rainfall occurs in the summer months, from October to

[41] The 52 basins include basins located in Tanzania, Malawi, Zimbabwe, Zambia, Swaziland and South Africa.

February. Precipitation in Mozambique varies tremendously from north to south and from the coast to inland. In the northern coastal area, the average annual precipitation is around 1,100 mm. In the Zambézia Province, the mean average precipitation reaches a local high of 2,000 mm. Figure 6 shows the average annual temperature and precipitation by month for the Lurio basin (New et al. 1999; for description see Appendix C). The diagram shows the relative humid season (hatched part of the diagram) and the arid season (dotted area) by combining the mean monthly temperature and precipitation curves.[42]

Figure 6. Relative aridity and humidity shown by average annual temperature and precipitation by month for the Lurio River Basin – SER A.



The northern region intersects the following main watershed basins: Rovuma, Messalo, Lurio, Licungo, Ligonha, and Shire. These rivers, outside of the Rovuma, originate from the high plateau, and are usually not perennial. The Rovuma River is the second largest river basin in Mozambique and forms the border with Tanzania.

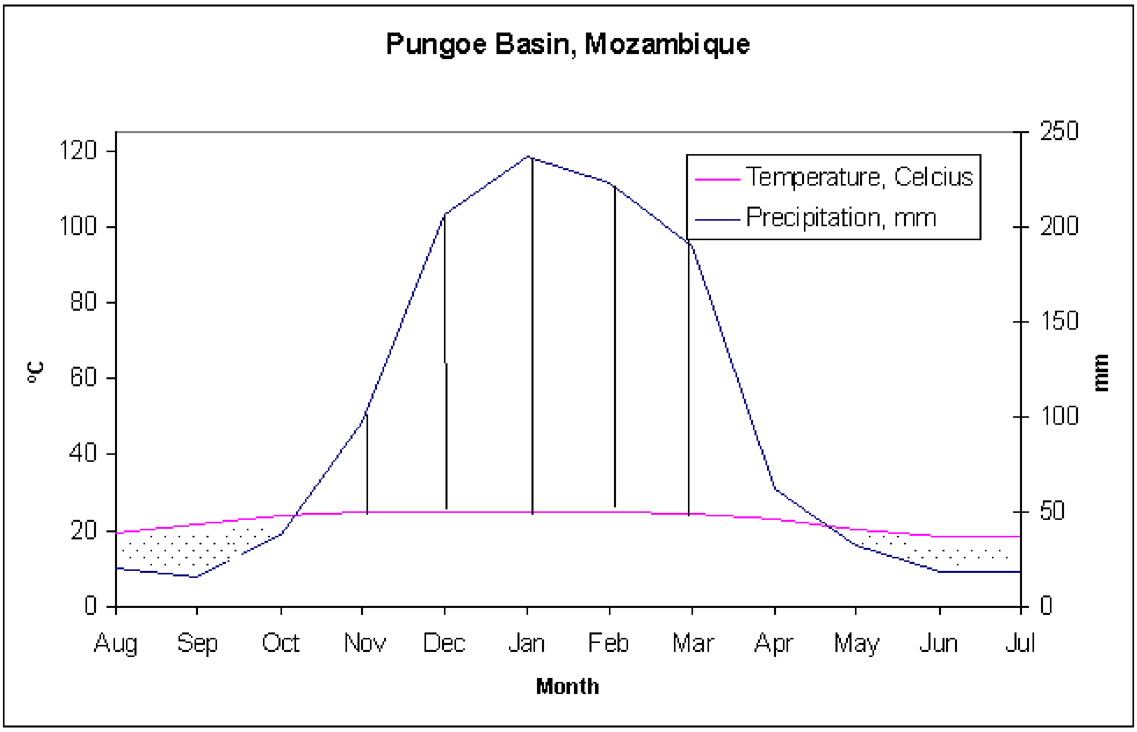
SER B -- Central Mozambique

The climate in central Mozambique is highly variable. The precipitation varies from a maximum mean annual average of 1,400 mm along the coast and in small inland pockets, to a minimum mean annual average of 500 mm in the Tete Province. The temperature gradient decreases from coastal lowlands to the interior highlands, exhibiting mean annual temperatures of 25°C and 20°C, respectively. Figure 7 shows the average annual temperature

[42] For detailed information on the diagrams, see Appendix B. The diagrams are based on the drawing rules of the climate diagrams by Walter (1985) and Walter et al. (1975).

and precipitation by month for the Pungoe basin (New et al. 1999; for description see Appendix C).

Figure 7. Relative aridity and humidity shown by average annual temperature and precipitation by month for the Pungoe Basin – SER B.



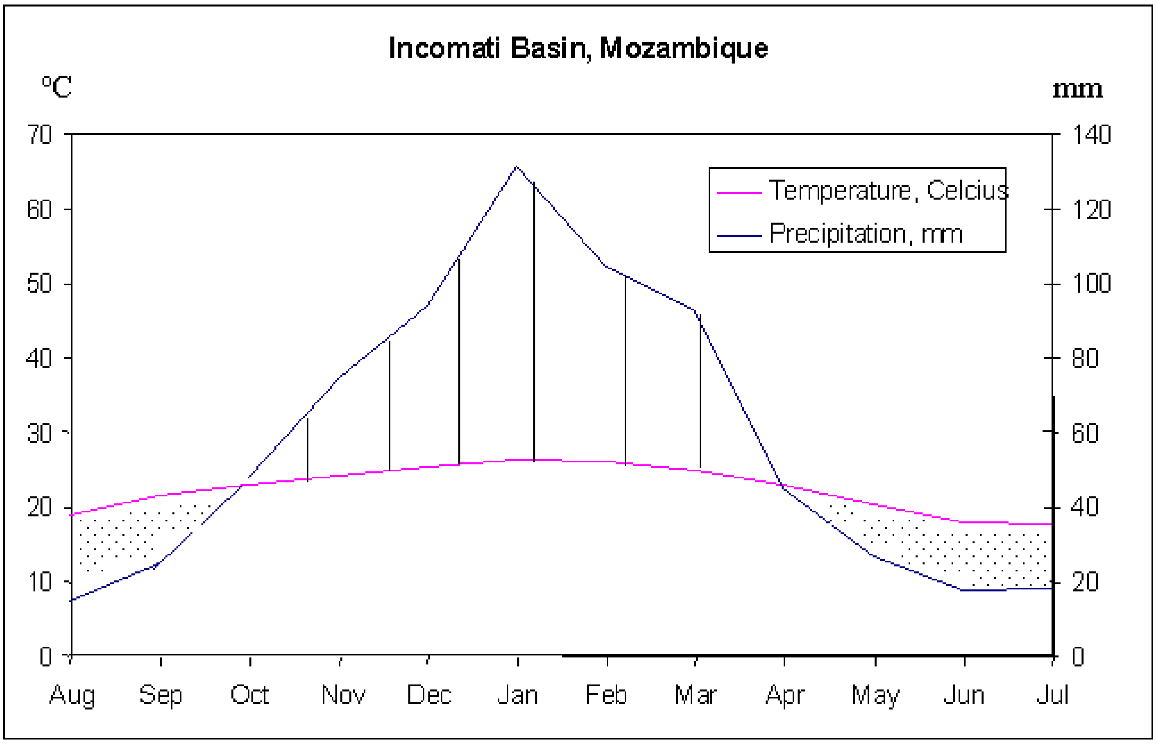
SER B is comprised primarily of the following watershed basins: the Middle and Lower Zambezi, the Pungoe, the Buzi, and the Save River Basins. The Zambezi River is the most important river in Mozambique. It constitutes about 50% of the water resources in the country and almost 80% of the hydropower potential. There is a commission that has been set up in recent years to oversee the management of the Zambezi River Basin. Eight countries share the Zambezi River Basin, the largest entirely within the SADC region, with a total population of 102.9 million people, of whom 30.8% live in the basin. The Zambezi basin is estimated to drain a total geographical area of about 1.3 million km^2, covering an area equivalent to an area slightly larger than Angola. The Zambezi River flows over a distance of nearly 3,000 km, dropping in altitude from its source in the Kaleen Hills of northwestern Zambia, at 1,585 m above sea level, to its delta in the Indian Ocean, 200 km north of the Mozambican port of Beira. Angola, Botswana, Malawi, Mozambique, Namibia, Tanzania, Zambia and Zimbabwe share the basin. Approximately 4 million Mozambicans reside in this basin.[43]

[43] The Zambezi Newsletter provides comprehensive information about the river basin: http://www.sardc.org.zw/imercsa/zambezi/Znewsletter

SER C – Southern Mozambique

The southern region, SER C, is composed of Gaza, Inhambane and Maputo Provinces. The capital city, Maputo, lies in Maputo Province and is discussed in more detail in the case study section. It comprises some of the driest parts of the country. The annual average precipitation for SER C decreases from a coastal high of about 1,000 mm to an inland low of 400 mm. The Limpopo River basin is the driest river basin, with an average annual precipitation level of 400 mm. The majority of rainfall occurs in the summer months, from December to March. The average annual temperatures vary from 23°C in the coastal areas to 25°C in the interior. Figure 8 shows the average annual temperature and precipitation by month for SER C (New et al. 1999; for description see Appendix C).

Figure 8. Relative aridity and humidity shown by average annual temperature and precipitation by month for the Limpopo Basin – SER C.



SER C is comprised primarily of the following watershed basins: Save, Changane/Limpopo, Incomati, Umbeluzi, and Maputo. The Incomati, Umbeluzi, and Maputo River basins are all international river basins shared with the Republic of South Africa and Swaziland. These basins are all prone to flood, due to their topographical characteristics and low elevations. In addition, upstream agricultural effluents from the upstream countries often decrease the water quality of these rivers.

The Limpopo River basin is an international river basin shared with the Republic of South Africa, Botswana and Zimbabwe. Of the total basin area of 412,000 km^2, 19.3% is within Mozambique. The Changane river represents one of the two main tributaries of the Limpopo, the other being the Elephants river. Most of the water demand in this basin is for irrigation. Before the war approximately 41,000 hectares of land were irrigated, which was reduced to 13,000 hectares after the war.

Thirty one percent of the Incomati River Basin lies within the borders of Mozambique, which is the most downstream. The Mozambican part of the basin is mostly a large floodplain. The main water demand is for irrigation, mainly for sugar cane (> 50%), rice, banana, cotton and vegetables. The Incomati River basin represents the main new water source that can be considered for future augmentation of the Maputo supply network. It is estimated that 2 m^3/s can be diverted.

The Umbeluzi River feeds the Pequenos Limbobos Dam, which represents the main water supply of the Maputo urban water supply. Approximately 41% of the river basin area lies within Mozambique, which is the most downstream part of the basin. Approximately 2,200 hectares of land are irrigated in the Umbeluzi basin, the majority of the irrigation is for citrus plantations.

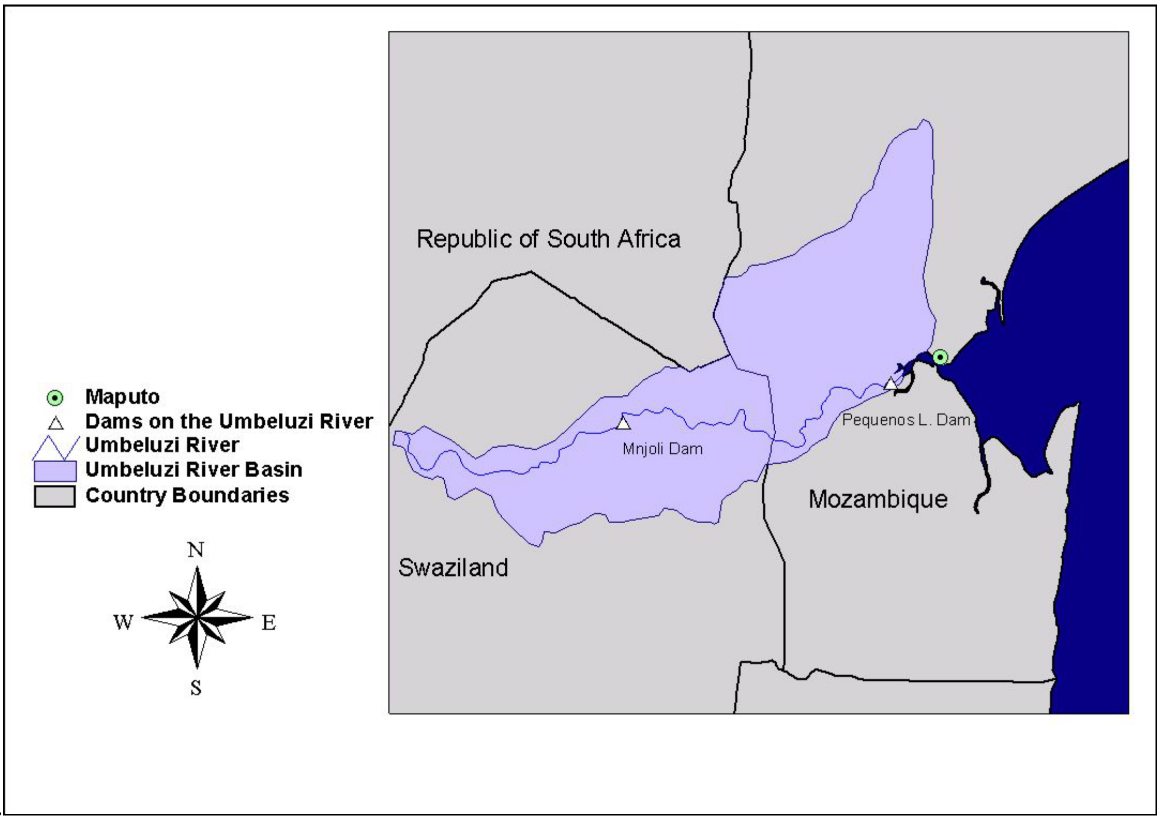
Mozambique is the furthest downstream on the Maputo river basin, of which only 5.3% of the area lies within Mozambique. There are no dams in the Mozambican part of the basin. In the past, the main water consumption was for the irrigation of 1,000 hectares of land, comprised mainly of rice, maize and vegetables. After the war only 10% are still in production (Consultec 1998).

Model Application: Maputo City

This section describes the modeling effort of the water supply of Greater Maputo (Maputo and Matola). Maputo, the capital city, is located on the southeastern coast of Mozambique. Including the major village of Matola, the population in 2001 of Greater Maputo was approximately 1.69 million. It lies within the Incomati River Basin, and on the far eastern edge of the Umbeluzi river basin, which were described in detail in the previous sections. Greater Maputo's water supply comes primarily from tributaries and groundwater sources within the Umbeluzi basin. This section differs from the work done above, in that it is a more detailed modeling effort of the water supply system, including the infrastructure that is currently being used.

Figure 9 shows the existing surface water infrastructure for Greater Maputo. Maputo relies on surface water from the Pequenos Limbobos Dam. The dam just northeast of the Pequenos Limbobos Dam, Mnjoli Dam, is located in Swaziland. An agreement between the two countries was made in 1976, which guarantees an annual flow of 91 MCM/a at the border. However, since Swaziland has only one major dam on the river the flow is currently higher than that number.

Figure 9. Maputo City water infrastructure.



The water supply of Greater Maputo is currently unable to provide enough water to meet the combined demands of its population, industry and agricultural users. Presently, only 29% of the population in Maputo/Matola have water in their homes; 21% take water from public taps. Half of the people in the cities do not have any piped water, but use wells. This will be exacerbated by the expected growth of demands by industry and agriculture, as a new aluminum plant is near completion and plans to increase upstream agricultural production are in place. Mozambique can improve water supply quantity by repairing systems that have broken down. For example, the water treatment plant does not currently operate at full capacity, and some of the pumps that transport water from the dam to the treatment plants are out of order as well. Figure 10 shows the water requirements for Maputo/Matola cities in 2001 and 2021. This assumes that 82% of the population is connected to the water system in 2021. Given this demand scenario, simulations of the water balance indicate there will be a supply deficit within the next ten years.

Figure 10. Water requirements for Maputo/Matola cities in 2001 and 2021. Note: This assumes an increase in connected water users from 50% to 82% by 2021.

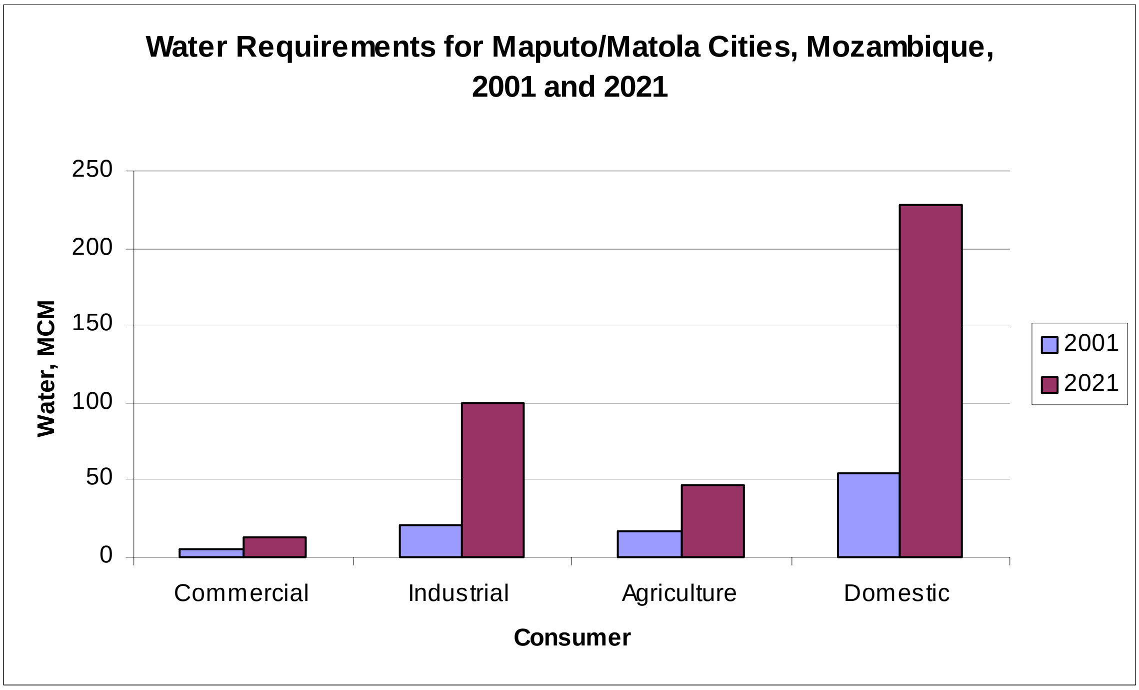
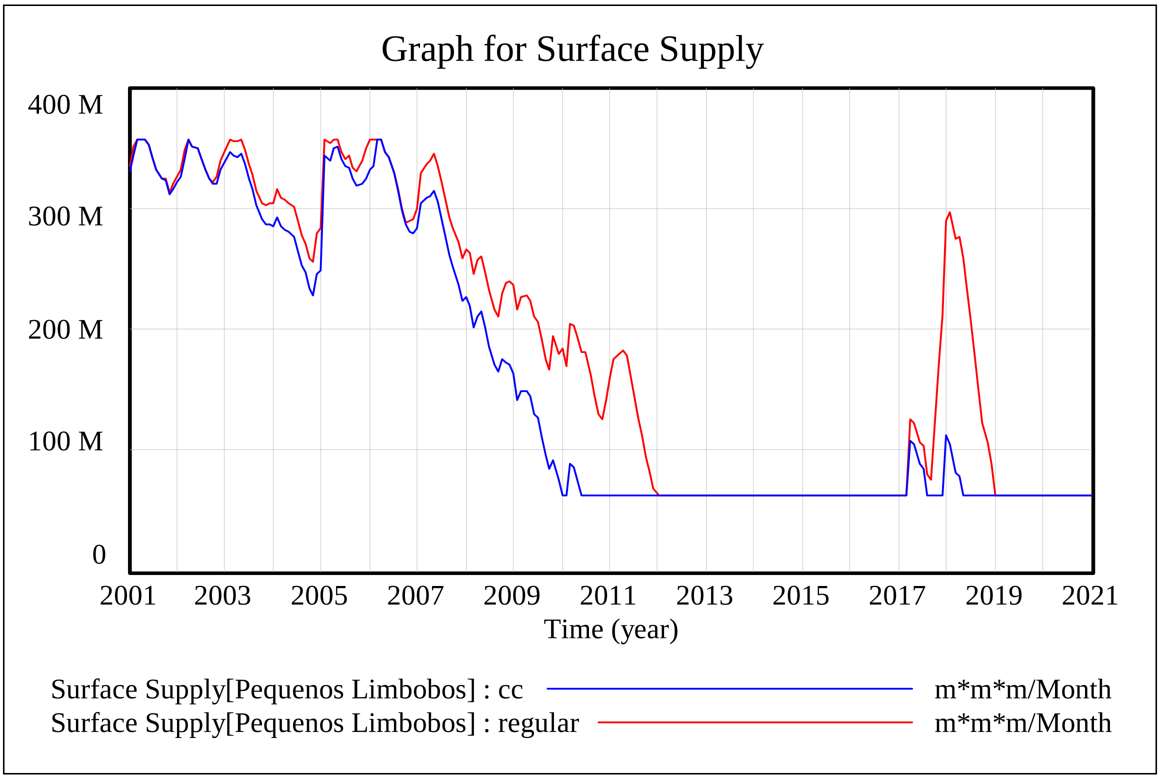


Figure 11 shows Greater Maputo's main supply dam under two different scenarios: No climate change and climate change. These supply scenarios incorporate the same demand scenario presented in Figure 10. Note that the climate series of future precipitation, temperature and vapor pressure is only one climate representation of many possible futures. This series is based on the historical precipitation, temperature and vapor pressure time series for the region. The climate change scenario presented here was derived from the Hadley Center's Global Circulation Model (Murphy 1995a, 1995b). The Hadley Center's GCM predicts an average temperature increase of about 1.8 degrees by the year 2021, a decrease in precipitation in the summer months and a slight increase in precipitation in the winter months. Notice that in the case of climate change, the supply deficit will occur approximately two years earlier than in the scenario where climate change does not occur.

Figure 11. Surface supply level of Pequenos Limbobos Dam with and without climate change effects.



Many of Mozambique's water-related problems will be caused by urbanization and the resulting increases in population and industrial-induced pressures on water resources. Earlier studies emphasized the fact that rapidly growing populations would lead to the rapid degradation of the natural resources of Southern Africa. In light of the HIV/AIDS epidemic, the severity of perceived future water scarcity has lessened somewhat, but still exists primarily in the urban centers. The direct incorporation of driving forces into the water demand model allows for more insightful results for water planners and social scientists alike.

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Appendix A: The Priestly Taylor Method for PET

The Priestly Taylor method is a radiation-based approach to modeling the PET. The net radiation can be taken from observed data or by analytical methods. For evaporation over very large areas, energy balance considerations largely govern the evaporation rate. For such cases Priestly and Taylor (1972) found that the aerodynamic energy could be approximated to be 30% of the radiation energy. Thus, fewer terms are required to give an accurate representation of the PET. For cases where available data is a limiting factor this method is very convenient.

Evaporation can be computed by two methods: the aerodynamic method and the energy balance method (Chow et al. 1988). The aerodynamic processes involve the removal of saturated air away from the surface (wind speeds). The energy method takes into account the energy required for the conversion of water to a vapor phase. These two methods can be used in conjunction or separately to compute PET. Penman (1948) defined perhaps the most well known combined method of estimating PET:

$$E = \Delta/(\gamma+\Delta)\, E_r + \gamma / (\gamma+\Delta)\, E_a \qquad \text{(A.1)}$$

where: E = the combined evaporation estimate (mm/day)

E_a= the evaporation estimate which assumes an unlimited amount of available energy.

E_r= the evaporation estimate which assumes that the ability of the system to remove moist air is not limiting.

Δ = the slope of the saturated vapor pressure curve.

γ = the psychometric constant = $C_p\, p\, K_h / (.622\, l\, K_w)$

where, C_p = specific heat at constant temperature, K_h and K_w are diffusivity parameters (L^2/t).

Priestly and Taylor (1972) found that for very large areas the second term in the above equation is about 30% of the first term (Chow et al. 1988). Thus an approximation to the Penman equation was derived:

$$E_{rc} = \alpha^* \Delta/(\Delta+\gamma)\, (R_n - G) \qquad \text{(A.2)}$$

where alpha has been assigned a value of 1.74 for arid climates and G is the soil heat flux, which for regional estimates can be assumed to be zero. E_{rc} is a reference crop evaporation estimate, which is referred to in this paper as PET. The reference crop estimate gives lower values of PET than free surface estimates.

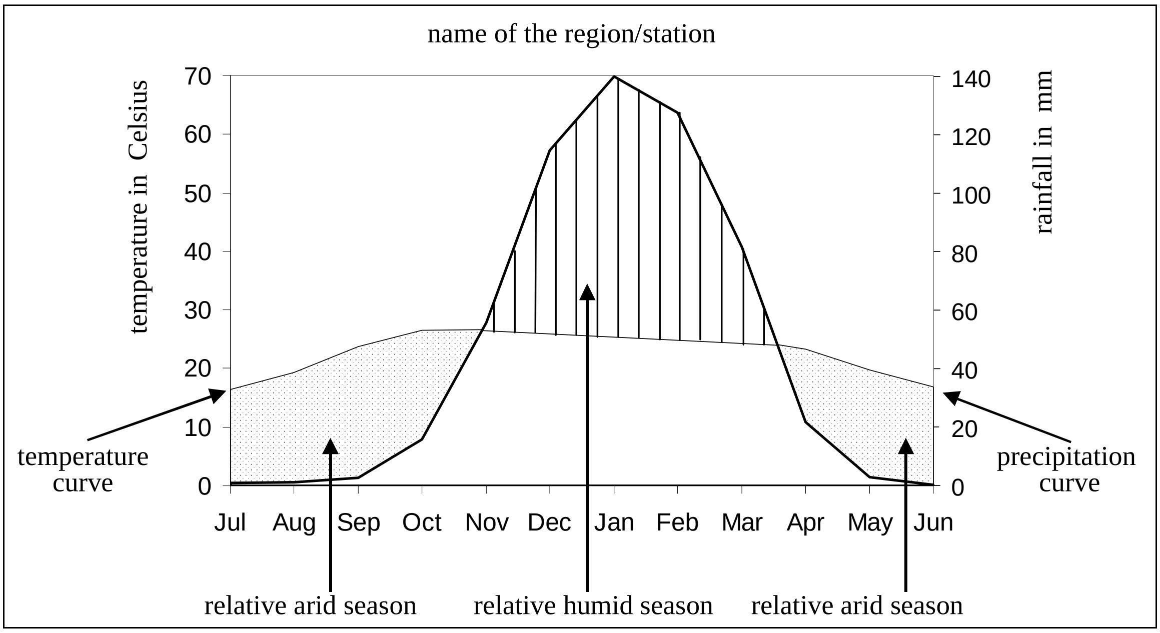
Appendix B: Description of Figures 6–8, after H. Walter

The diagrams used in this report to describe regional climates are taken after Walter (1985) and Walter et al. (1975).

The diagram below provides a basis for interpreting the climate from an ecological perspective. It combines monthly temperature and precipitation curves for a specific region, in order to show periods of relative humidity and aridity. The water balance for a region is more accurately described by using potential evaporation and precipitation, which have the same units, to describe the input and output of water into a region. In this case, the temperature is used as a relative measure of the potential evaporation, because the two measures are proportional. However, as the climate becomes more arid, the absolute difference between the temperature and potential evaporation increases. For this reason, the diagram should only be interpreted as a relative comparison of humid and arid periods.

The diagram juxtaposes the temperature and precipitation in a fixed ratio of 10^{o}C to 20 mm precipitation. This ratio has been derived from empirical studies, and can be applied to all regions of the world with the exception of the ecological zone of the Steppe (10^{o}C = 30 mm). The diagram plots values for every month of the year. In the southern hemisphere, the time axis runs from June to July, while for the northern hemisphere it runs from January to December. This ensures that the warmer season be located in the middle of the diagram.

Finally, the magnitude of the vertical spread of the two curves provides a relative measure of the intensity of the humid or drought periods, while the horizontal extent of the shaded areas provides a measure of its duration.



Appendix C: Description of the Links Dataset

New et al. (1999) is used for climate data for Mozambique as well as in all the southern African countries.

The climate time series used for Mozambique is a 0.5x0.5 degree lat/long gridded dataset of monthly terrestrial surface climate for the period 1901-1996. The dataset is comprised of seven climate variables including precipitation, mean temperature, diurnal temperature range, wet-day frequency, vapor pressure, cloud cover and ground-frost frequency. Fields are derived as climate anomalies relative to a 1961 to 1990 base period, which were then interpolated from climate station data to the grid. The anomaly grids were then added back to the 1961-1990 mean monthly climatology to arrive at the monthly climate over the 96-year period.

Precipitation and temperature were interpolated directly from station observations and the resulting time series were compared with other, coarser resolution datasets of similar temporal extent. The remaining, secondary variables were interpolated from merged datasets, comprising station observations and where data were sparse, using synthetic data estimated using predictive relationships derived from the primary variables.