Namibia's Future

Modeling Population and Sustainable Development Challenges in the Era of HIV/AIDS

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Executive Summary
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Foreword

Science, like government, tends to be compartmentalized into disciplines. A division of labor is useful because it allows for in-depth expertise and efficient action. The only problem is that the real world is not compartmentalized, and changes in population, development, and environment are interwoven. Over a short time horizon these intersectoral dependencies may not be very important, but over a long planning horizon it becomes imperative to address a country's future in a comprehensive interdisciplinary and interministerial manner.

This type of comprehensive analysis of long-term future options has been the explicit goal of this project, which combines more traditional descriptive analysis with interactive computer modeling. The project has been carried out in the context of a population–development–environment (PDE) framework of analysis, developed at IIASA over the past decade and applied to earlier case studies, with close substantive collaboration between IIASA and the national partner institution. Such collaboration between national and international experts, which lies at the heart of the PDE approach, also proved to be a highly successful strategy in this case.

This Executive Summary is only one output from the project. Major scientific books documenting the work in detail will soon be available, along with a CD-ROM and a Web site (www.iiasa.ac.at/Research/POP/pde/) with the full computer model and other important documentation that will allow the user to personally evaluate alternative strategies and scenarios toward the country's sustainable future development.

It is our hope that these findings will be discussed in both academic and political circles at the national and international levels, and that this discussion may lead to closer collaboration among countries in the Southern African region on these vital longer-term challenges.

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Acknowledgments

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No project of this magnitude happens without the help of many people. Marilyn Brandl helped organize the work and cheerfully typed, edited, and coordinated many versions of this document. Isolde Prommer produced the CD-ROM that contains the models underlying the findings presented here. Together with Ben Fuller, she edited the volume Population–Development–Environment in Namibia: Background Readings (IIASA Interim Report, IR-00-031, May 2000), which contains valuable information on Namibia, some of which was used in the computer models that are the basis of this report. She also played a crucial role in coordinating the efforts of project participants, who were often on different continents, and in arranging the conference in Windhoek on March 14, 2001, where the results of the research were presented. Alyssa Holt did the research underlying our findings on water demand. David Yates helped with the design and parameterization of the water supply model. Annababette Wils helped program the Namibia Demographic Model. Wolfgang Lutz, the leader of the Population Project at IIASA, provided encouragement and insightful comments throughout the process. When our focus wavered, he always brought us back to reality.

We give special thanks to Kuberin Packirisamy, who, despite personal tragedy, did a brilliant job of programming the core of the Namibia Demographic Model. This project would not have been the same without his untiring work.

Main Findings

1. Namibia is likely to have little population growth over the next two decades.
2. The data collected by the Sentinel Surveillance Surveys are inadequate, but are being improved.
3. Although Namibia is likely to have little population growth in the next two decades, urbanization will continue. Namibia's rural population will decline in size.
4. There will be a substantial increase in the number of people in the labor force with a secondary school education or above, and an absolute decrease in the number of people with a primary school education or less.
5. Deaths from HIV/AIDS will change the age structure of the adult population.
6. There is no suggestion of a near-term economic catastrophe.
7. The effects of changes in the trade regime by themselves will increase Namibia's rate of economic growth.
8. A program that provides HIV/AIDS medication to everyone who could use it would cost around 5% of the Government's revenue by 2021 at today's (reduced) prices. The percentage increase in per capita output from keeping more people alive would be greater than the increase in per capita taxes that would be required to finance the campaign.
9. In the past, high levels of unemployment and underemployment have been problems. These problems will slowly improve over the next two decades.
10. Namibia will face increased water stress over the next 20 years as a result of urbanization and economic growth.
11. Without further conservation measures or new water supplies, Windhoek will experience high water stress.
12. Withdrawals from the Kavango River are not necessary to provide water to Windhoek. Conservation and other water infrastructure will suffice.
13. Climate change models produce inconsistent implications for future levels of water stress. Prudence suggests preparation for increasing water shortage.

Introduction

In 1997, the International Institute for Applied Systems Analysis (IIASA, Laxenburg, Austria) began a research project, funded by the European Union, on future population, development, and environment interactions in Botswana, Mozambique, and Namibia.

All the results presented here are based on detailed computer simulation models calibrated to data from the 1990s. These models and information on how to run them are available on CD-ROM and on IIASA's Web site: www.iiasa.ac.at/Research/POP/pde/. This work is the continuation of a series of projects on population, development, and environment interactions that includes studies of Mauritius, Cape Verde, and the Yucatán peninsula of Mexico. Parallel Executive Summaries have been prepared for Mozambique and Botswana. A volume comparing Botswana and Namibia and a separate volume on Mozambique are in preparation. Working drafts of the chapters of those volumes are posted on the IIASA Web site as they become available: www.iiasa.ac.at/Research/POP/.

Our philosophy has been much the same throughout all our projects. We create models that are detailed, stay close to the data, and integrate population, development, and the environment. This Executive Summary presents our main findings for Namibia.

Namibia is a young country, having achieved its independence only 11 years ago. It is a land of great potential. The extent to which this potential will be realized is dominated by one issue, the effects of HIV/AIDS. Currently, Namibia has one of the highest HIV/AIDS prevalence rates in the world. In 2001, around 18,000 or about 1% of Namibia's population will die of AIDS. This number will almost double in the next 10 years. Even with significant changes in behavior, our model shows that over half a million Namibians will die of AIDS from 2002 to 2021. This is roughly a third of Namibia's current population. This report summarizes our findings on how HIV/AIDS will influence population, development, and environment interactions in Namibia during the next two decades.

Main Finding (1): Little Population Growth

Here we present five population scenarios: (1) a continuation of the behavior exhibited in 1994–1998, modified to take into consideration current efforts to reduce the transmission of HIV from mothers to their children; (2) a situation in which government education efforts are successful in reducing the riskiness of people's behavior; (3) a government program of providing HIV medication to some of the population; (4) a government program of providing HIV medication to all those who can tolerate it; and (5) the elimination of all new HIV infections beginning January 1, 2002, through the use of a fully effective vaccine.

Figure 1 shows the population of Namibia in the two extreme scenarios, the continuation of current behavior and the deployment of a fully effective vaccine at the beginning of 2002. The population of Namibia is currently (2001) around 1.82 million people. Ten years from now, Namibia's population will be 1.93 million in the CONTINUATION scenario and 1.99 million in the VACCINE 2002 scenario. The difference is small because there is a long period between

Box 1. The Namibia Demographic Model.

We have produced a detailed model of Namibia's population and run it from 1994 through 2021. It includes the population disaggregated by 100 single years of age, sex, three education levels, two types of sexual behavior (risky and not risky), four HIV statuses (HIV-negative; HIV-positive, asymptomatic and unmedicated; HIV-positive, asymptomatic and medicated; and AIDS), 15 single years since infection (for those HIV-positive, asymptomatic and unmedicated), and whether a young person has initiated sexual activity or not. The initial age-, sex-, and education-structure of the population is taken from the 1991 census, updated to 1994. Age-, sex-, and education-specific rates of HIV spread are derived from Sentinel Surveillance Survey data from 1994 and 1998, corrected, as best as possible, for biases resulting from the nonrepresentative nature of those data augmented by a few assumptions that can be changed by model users.

infection with HIV and death. Most of the people who would become HIV positive between 2002 and 2011 in the absence of a vaccine would survive to 2011 in any case. By 2021, the difference in population size is naturally much larger. In the CONTINUATION scenario, the population would fall slightly to 1.89 million, while in the VACCINE 2002 scenario it would rise to 2.35 million. In the CONTINUATION scenario, the annual rate of population growth over the two decades is essentially zero. In the VACCINE 2002 scenario, the annual rate of population growth is 1.27%. Both of these cases are unlikely, but they provide plausible upper and lower bounds on Namibia's 2021 population size.

Within the next two decades some behavioral changes will almost certainly occur. Government programs to produce these changes are already being put into place. Within the next two decades, as Namibians get wealthier and the price of HIV medication becomes cheaper, HIV medication will begin to be used. Figure 2 shows Namibia's future population size under a behavioral change scenario and two medication scenarios.

These scenarios are three among the vast number that can be created with the software that we have made available. They are meant to be illustrative. The BEHAVIORAL CHANGE scenario assumes that the riskiness of sexual behavior begins to decrease in 2003. Between 2003 and 2007, the probability of

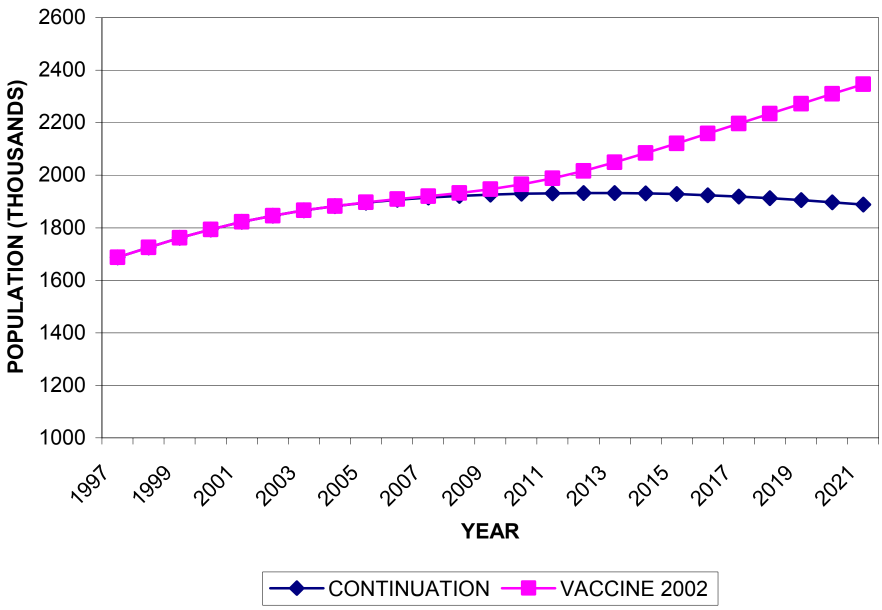

Figure 1. Population of Namibia under two extreme scenarios.

infection declines by 25% among those with primary schooling or less, 40% among those with secondary education, and 50% among those with tertiary education. These behavioral changes have a cumulative effect. If fewer people engage in risky behavior, fewer people become infected with HIV and consequently there are fewer HIV-positive people around to infect others in the future. Thus, the long-run decline in HIV prevalence is greater than the percentages by which risky behavior is reduced.

In the PARTIAL MEDICATION scenario, medication use is initiated when an HIV-positive person first becomes symptomatic and ends when the medication is no longer helpful. We assume that the medication increases life expectancy by, on average, 10 years. There is no way of knowing the extent to which medication will increase the life expectancy, but the constant mutation of the HIV virus suggests that medications will become less effective over time. In 2003, 10% of those with primary education or less who become symptomatic receive medication, 15% of those with secondary education, and 20% of those with tertiary education. These differences could be due to differences in the ability to pay for the medication. The percentages receiving medication increase to 30%, 45%, and 60% for the low-, medium-, and high-education groups, respectively, by 2005 and stay at those levels through 2021. In the FULL

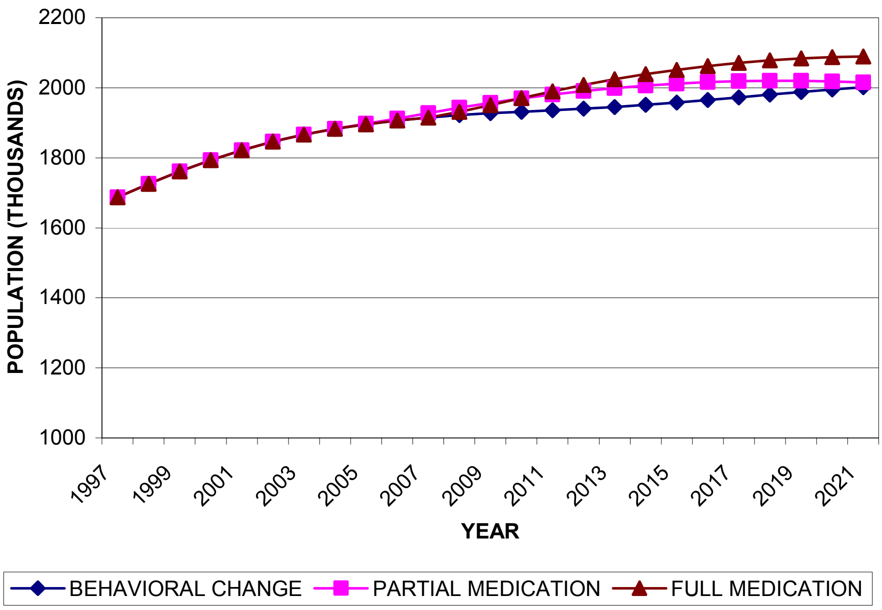

Figure 2. Population of Namibia under a behavioral change and two medication scenarios.

Box 2. HIV/AIDS forecasting.

An important equation used in forecasting populations like Namibia's is the prevalence–incidence relationship. In our case, we used:

$$IR(age,education,year) = k(age,education) \cdot MAMPR(age,education,year)^{\beta}.$$

$IR(age,education,year)$ is the fraction of uninfected women in a particular age and education group in a given year who become infected during that year.

$k(age,education)$ is a set of age- and education-specific constants that are derived from two observations on HIV prevalence rates. In the case of Namibia, these observations are from 1994 and 1998.

$MAMPR(age,education,year)$is a moving-average modified prevalence rate. It takes into account the prevalence rates in a five-year window centered on the specified age and takes into account differences in risky sexual behavior of population groups and differences in the likelihood of spreading HIV depending on whether the infected person is on medication or not.

β is a parameter that is determined by the distribution of risky sexual behavior in the population.

MEDICATION scenario, 70% of the people who become symptomatic, regardless of education, receive medication beginning in 2006. This scenario is called FULL MEDICATION because it is assumed that 30% of those who become symptomatic cannot tolerate the medication.

In the BEHAVIORAL CHANGE and the PARTIAL MEDICATION scenarios, Namibia's population increases at an average annual rate of five-tenths of one percent between 2001 and 2021. In the FULL MEDICATION scenario, Namibia's population grows roughly seven-tenths of one percent per year and is around 15% higher in 2021 than it is in 2001. There are, of course, many possible scenarios, including those with both behavioral change and medication. We have run quite a number of these and all plausible scenarios show little population growth in Namibia's near-term future.

Main Finding (2): Inadequate Data

The only data on the prevalence of HIV/AIDS that can be used for making population forecasts are the Sentinel Surveillance Survey data, which are derived from women seeking prenatal care. There are no data on men and therefore no way of modeling the transmission from women to men and vice versa. The Sentinel Surveillance Survey data come from small, nonrepresentative, and geographically biased samples with no information on the women except their ages and the fact that they are pregnant. Pregnant women are not representative of all women of reproductive age. They are certainly younger, on average. Even holding age constant, pregnant women are not a representative group. If less-educated women of a given age are more likely to have children than more-educated women of that age, but have lower HIV prevalence rates than those women, reported rates are biased downward. The HIV prevalence rate of young women is certainly biased upward because young pregnant women are all sexually active and therefore not representative of a group where some of the women are not yet sexually active. A very significant bias is the one introduced by the relationship between HIV and fertility. HIV-positive women are less able to have a child than similar HIV-negative women. This imparts a significant downward bias to the Sentinel Surveillance Survey rates. The Sentinel Surveillance Survey data are somewhat useful for describing aggregate trends, but they are very poor for analysis.

Namibia is in the midst of collecting better data as part of an overall strategy to combat HIV. Regional HIV/AIDS coordinators recently have been appointed to each of the 13 Regional Councils. Regional HIV/AIDS Action Plans are or will be drafted. These Plans are to include region-specific monitoring programs that go beyond the limitations of the Sentinel Surveillance Surveys.

Main Finding (3):
Urban Population Increase / Rural Population Decrease

Figure 3 shows the numbers of urban residents in the CONTINUATION, VACCINE 2002, and BEHAVIORAL CHANGE scenarios. Over the period 2001–2021, the urban population grows by 29.2%, 61.1%, and 38.5%, respectively, in the three scenarios. In the PARTIAL MEDICATION scenario and the FULL MEDICATION scenario, the urban population grows by 39.2% and 43.0%, respectively. Excluding the two extreme scenarios, our model predicts urban population growth rates of around 1.5% per year. Windhoek currently has around 219,000 inhabitants. By 2021, we expect its population to increase by over 50%. In the BEHAVIORAL CHANGE scenario, Windhoek's

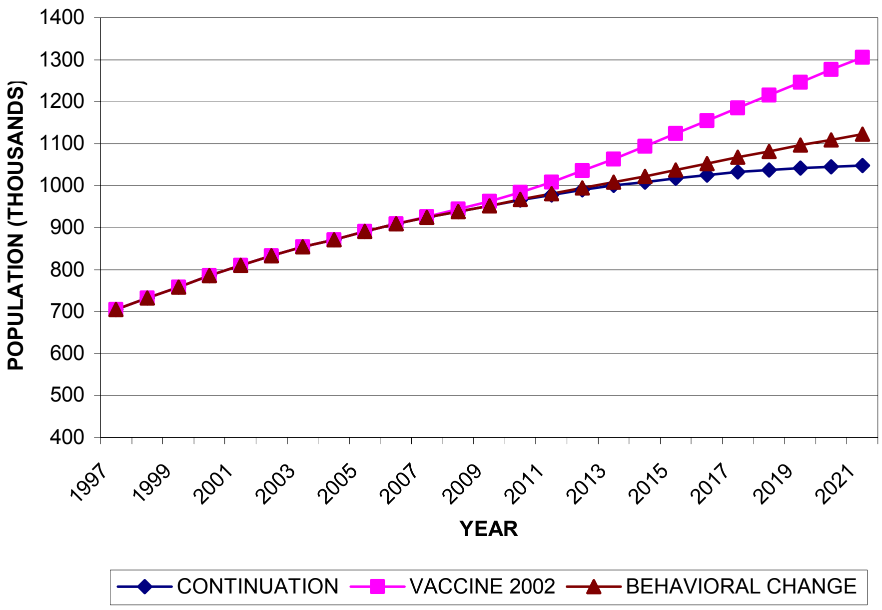

Figure 3. Urban population of Namibia under three scenarios.

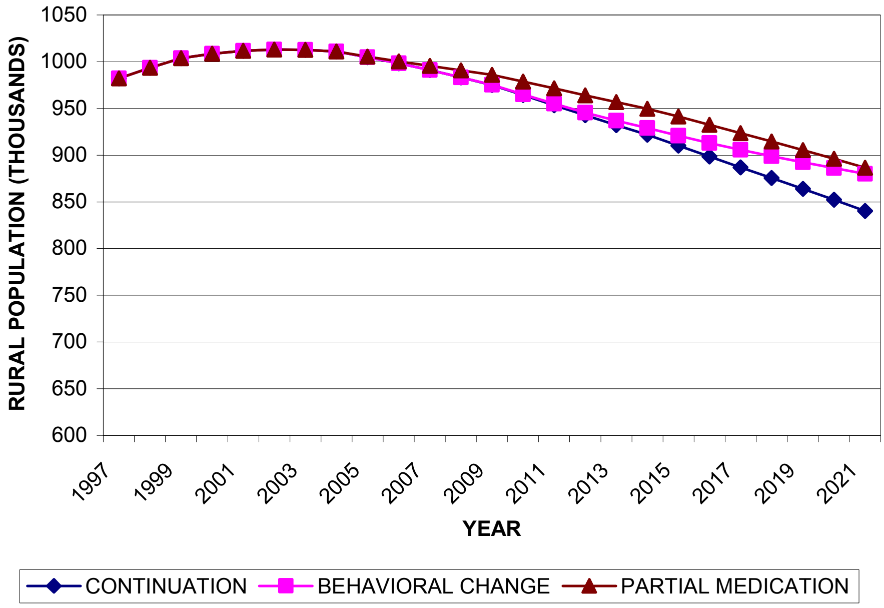

Figure 4. Rural population of Namibia under three scenarios.

population will be nearly 340,000 in 2021. This has significant implications for balance between water supply and water demand in Windhoek.

An increasing urban population and a constant total population imply that the rural population of Namibia will decrease in size. Figure 4 shows the size of Namibia's rural population according to the CONTINUATION, BEHAVIORAL CHANGE, and PARTIAL MEDICATION scenarios. In all the scenarios the rural population declines. Currently, the rural population of Namibia consists of around 1,011,000 people. In the CONTINUATION scenario, it would fall to 840,000 in 2021, a decrease of around 17%. In the other two scenarios, the rural population falls to around 883,000, a decline of roughly 12%. When we discuss the labor force below, we will see that rural employment is likely to fall faster than the rural population, causing an increase in the ratio of the rural population below the age of 15 and above the age of 50 to the total rural population.

Main Finding (4): Rapid Increase in Educated Labor Force

Because of past increases in enrollment rates, Namibia is in the midst of an era of rapid increase in the number of people with secondary and tertiary education. The HIV epidemic will not change this. Indeed, if more-educated people are more likely to change their behavior, or if they are more likely to receive medication for their infections, HIV could increase the size of the more-educated labor force even more. Figure 5 shows the labor force by two education groups, those with primary education or less and those with secondary education or more. These figures are based on the aggregate labor force participation rates observed in the 1991 census. Those activity rates will

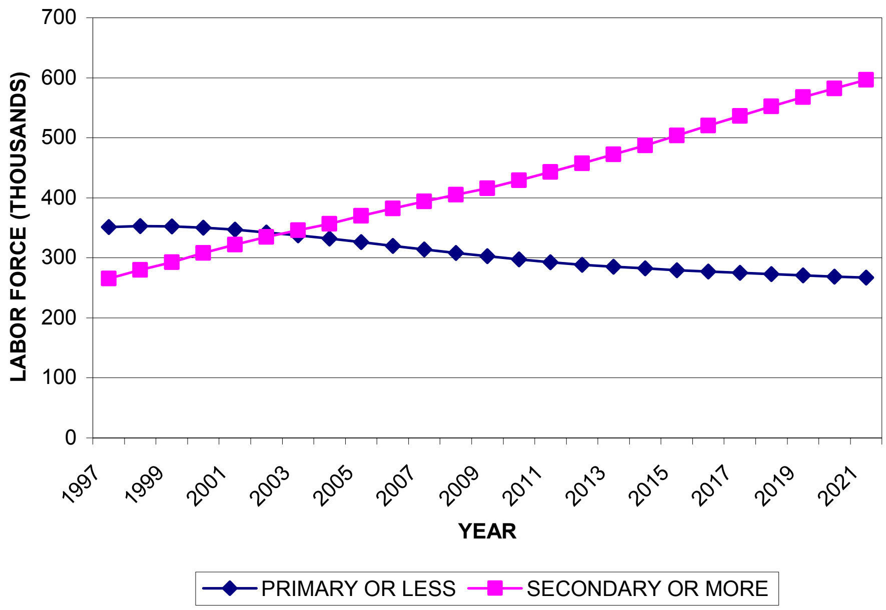

Figure 5. Namibia's labor force by level of education: BEHAVIORAL CHANGE scenario.

Box 3. Namibia spends an unusually high percentage of its government revenue on education.

Namibia has one of the world's highest rates of investment in education as a percentage of its government revenue. Currently that rate is over 20%. Although the educational system has high grade repetition rates, this vast investment program is now bearing fruit.

certainly change, but keeping them constant here is useful because the graph represents only the underlying education structure.

Using the 1991 economic activity rates, we calculate that the labor force currently consists of around 347,000 people with primary education or less and around 322,000 people with secondary education or more. At this time, the size of the less-educated portion of the labor force is shrinking and the size of the more-educated labor force is growing. In the BEHAVIORAL CHANGE scenario, the two paths cross between 2002 and 2003. Assuming the 1991 rates of labor force participation (economic activity), the more-educated labor force will grow by around 85% from 2001 to 2021, while the less-educated labor force will shrink by around 23%. Finding jobs for the increasing number of more-educated workers will be one of the chief challenges facing policy-makers in Namibia in the next two decades, despite the high death rates due to HIV/AIDS.

Education and skills are not the same thing. It is possible that the education system does not always produce the skills needed in the economy. Our research suggests that in the 1990s there were a significant number of people in the labor force with secondary education who held unskilled jobs.

Main Finding (5): HIV/AIDS Changes the Age Structure of the Adult Population

HIV/AIDS mainly kills people 30–39 years old. To see the effects of HIV/AIDS on the age structure, in Figure 6 we plot the number of people aged 20–29 and 40–49 in the BEHAVIORAL CHANGE scenario. In 2001, our model shows around 325,000 people aged 20–29 and around 140,000 people aged 40–49. By 2021, the number of people aged 20–29 is forecasted to grow to around 465,000, an increase of 43%, while the number of people aged 40–49 is expected to grow to around 147,000, an increase of 5%. The near constancy of the population aged 40–49 in contrast to the rapid growth of the population aged 20–29 provides a clear reminder of the considerable loss of human capital caused by HIV.

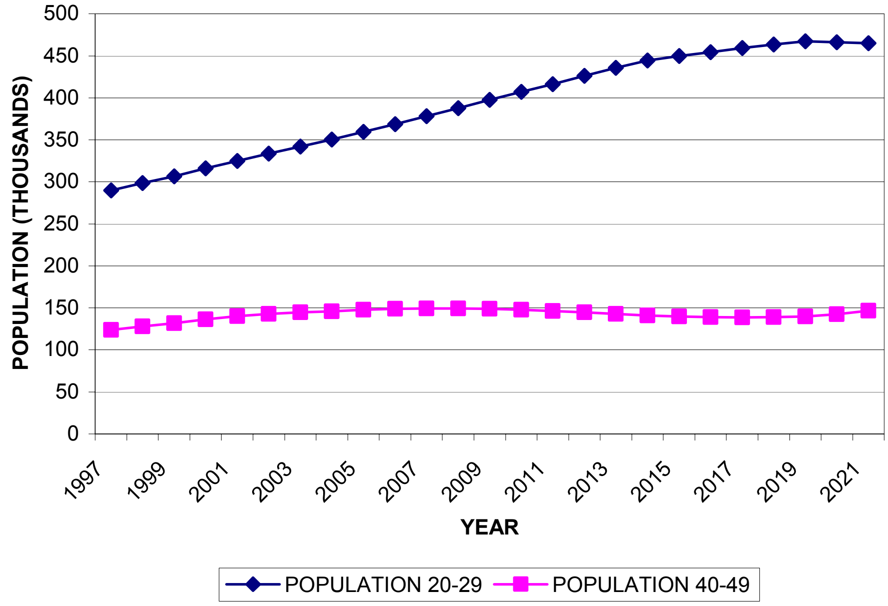

Figure 6. Number of people aged 20–29 and 40–49: BEHAVIORAL CHANGE scenario.

Main Finding (6): No Economic Catastrophe

The economy of Namibia is driven by exports and constrained by a shortage of skilled workers. Unskilled workers are in abundant supply. The country has an unemployment rate well in excess of 20%. Namibia's exports include diamonds and other minerals; animals, fish, and processed products made from them; and tourism. HIV could affect the economy through three main routes: (1) it could reduce exports, (2) it could diminish the number of skilled workers, and (3) it could reduce investment. The direct costs of HIV, such as additional health care costs, influence the economy mainly by decreasing investment. HIV also causes a reallocation of consumption expenditures from other goods and services to health care. This sort of reallocation has little economic effect (see Box 7). The situation in Namibia is different from that in many other African countries with high HIV prevalence. None of Namibia's exports are particularly sensitive to its population size. The production of diamonds and other minerals takes only a

Box 4. The Namibia Economic Model.

Our results are based on a newly constructed three-sector general equilibrium model of the Namibian economy. The three sectors are non-agricultural exports, non-tradables, and agriculture, including manufacturing based predominantly on agricultural inputs. The non-agricultural export and non-tradable sectors are represented with nested constant elasticity of substitution production functions. Agricultural output is based on a Cobb-Douglas production function. Gross output in all sectors includes intersectoral flows and imports.

Available quantities of skilled and unskilled workers, as well as the number of people on HIV medication are derived from the Namibia Demographic Model (see Box 1). The skilled wage is assumed to clear the labor market, but unemployment of unskilled workers is allowed.

The model includes a representation of the Government's approach to balancing its deficit, on one hand, with the need for economic growth, on the other, and the effect of expected changes in Namibia's foreign trade environment.

small proportion of Namibia's labor force. Fishing also employs few people. Animal production employs more, but there is such substantial under-employment that fewer people could certainly raise the same number of animals. Tourism may be sensitive to the prevalence of HIV, but tourism might also be sensitive to the extent of unemployment, which is reduced by HIV. In brief, it is not clear that HIV will have a substantial effect on the growth of Namibia's exports. In the near-term future, Namibia's exports will increase as a result of the new Skorpion zinc mine and the development of the Kudu gas field. Neither has much to do with Namibia's population growth rate.

High HIV/AIDS death rates will certainly reduce the number of skilled workers, but as we saw in Main Finding (4), the number of people in the labor force with a secondary education or more is expected to increase by around 85% between 2001 and 2021 anyway. It will be a major challenge for the economy of Namibia to absorb this large increase in skilled labor. Thus HIV/AIDS will not cause a shortage of skilled workers.

HIV could cause a decrease in investment. In other countries the mechanism for this would be a decrease in savings. Since independence, savings in Namibia has generally exceeded investment. Investment is driven

Box 5. Namibia's "tiger cub" economy.

Namibia has a small open economy whose growth is driven mainly by exports. The most important exports are those of the mining sector, particularly diamonds, and those of the agricultural sector, ranging from live animals to fish oil. From 1995 to 1999 Namibia had an average economic growth rate of 3.8%. With a stable political system and new exports expected to come on line soon, the short-term future looks bright.

Box 6. Sound macroeconomic management.

The Government of Namibia has produced a stable, business-friendly environment. It has eliminated exchange rate risk with South Africa by joining the Common Monetary Area (CMA), which means that the Namibian dollar exchanges one to one with the South African rand. Namibia and South Africa are bound together exactly in the same way that Euro-zone countries are. This arrangement constrains both the monetary and the fiscal policies of the Namibian Government. These sorts of constraints are included in the Namibia Economic Model.

more by profitability than by savings. HIV could also decrease profitability by driving up the costs of skilled labor, but this effect is captured in our model.

The rate of real per capita output growth is shown in Figure 7 for the CONTINUATION and VACCINE 2002 scenarios, and in Figure 8 for the other three scenarios. We use only one economic scenario here in order to keep our

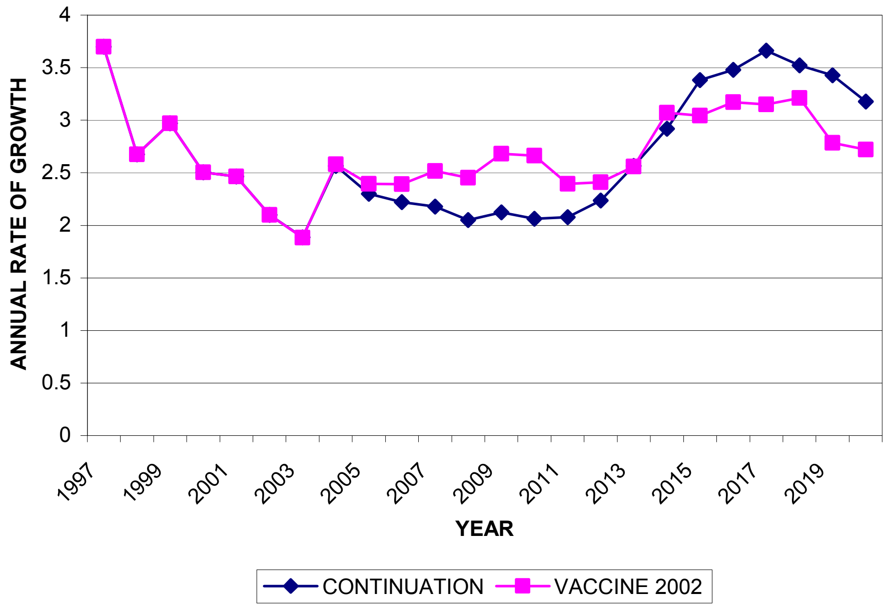

Figure 7. Annual rate of growth of per capita real gross domestic product in the two extreme scenarios.

Box 7. Gross Domestic Product is a poor measure of welfare.

Gross Domestic Product (GDP) does not capture the suffering caused by HIV/AIDS. From the perspective of national income accounting, food served at a wedding is identical to food served at a funeral. If a child is orphaned, the pain felt by the child does not decrease GDP, nor does the pain felt by the child's grandparents' having been cut off from the emotional and financial support of their own dead children. If the orphaned child goes to live with his or her elderly grandparents, and the grandparents are induced to work longer hours to care for him or her, GDP actually increases.

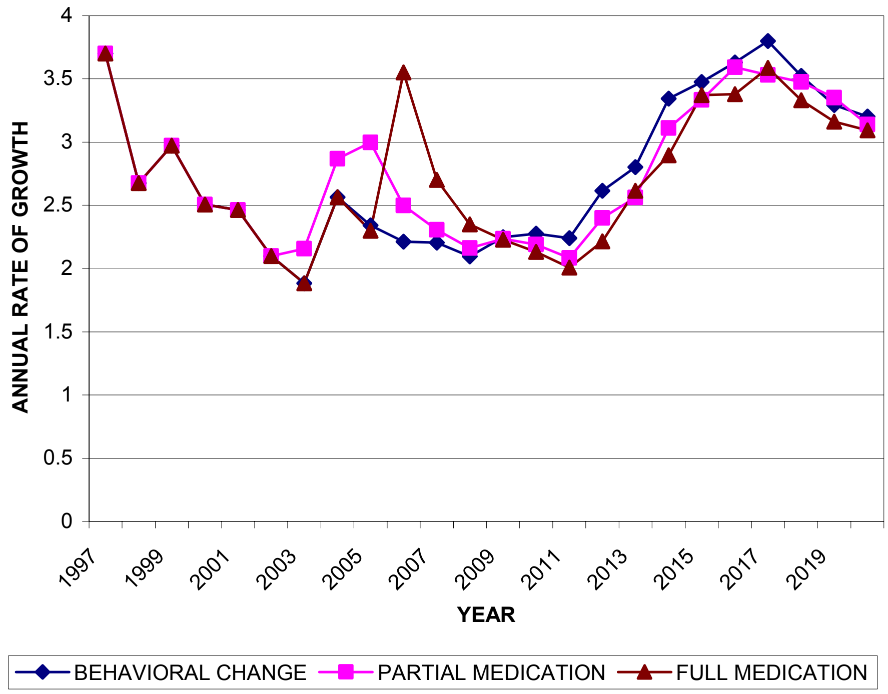

Figure 8. Annual rate of growth of per capita real gross domestic product in three scenarios.

discussion clear. The economic scenario is designed to reproduce the major trends in the Namibian economy, not its exact year-to-year changes.

In all five population scenarios, a growth rate of per capita output of around 2.5% per year is maintained throughout the current decade. In the following decade, the economic growth rate rises to over 3% per year. The main point is clear: HIV/AIDS will not cause an economic catastrophe in Namibia.

Main Finding (7): Trade Regime Changes Will Increase Economic Growth

In Figure 9, we consider how expected changes in Namibia's trading regime interact with the changes caused by HIV/AIDS. In the context of the BEHAVIORAL CHANGE scenario, we see that decreases in tariff rates result in considerably faster economic growth. In our baseline economic scenario, tariffs decline by around 90% from 2002 through 2021. Since the tariff changes are to be introduced only slowly, the effect is seen most clearly after 2015. Over the 20-year period, output grows by 88% assuming the decreases in tariffs that are built into Namibia's current trade arrangements and only by 64% without them. The average rate of economic growth is 3.2% with the tariff reductions

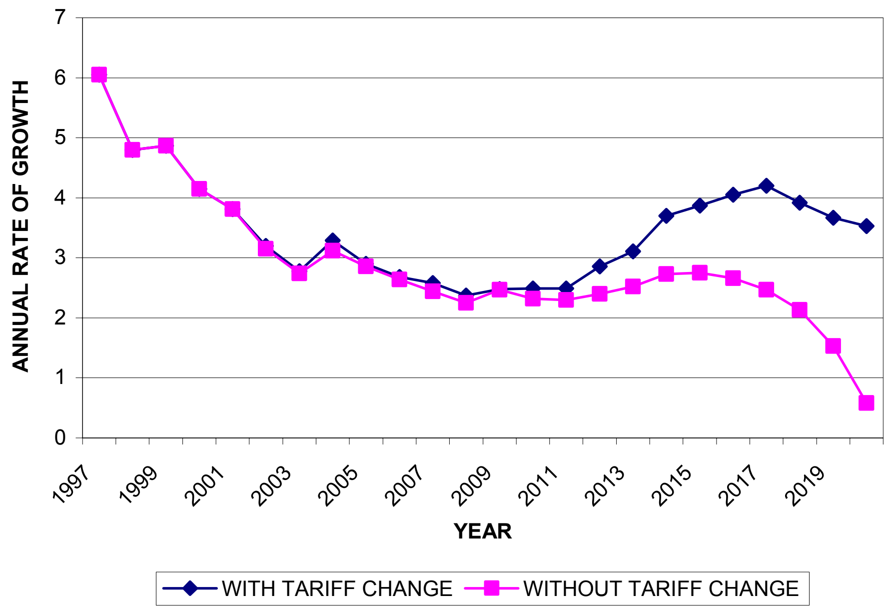

Figure 9. Annual rate of growth of real gross domestic product with and without expected tariff decreases: BEHAVIORAL CHANGE scenario.

Box 8. The challenge of changing foreign trade regimes.

In addition to HIV/AIDS, Namibia will have to cope with a rapidly changing trade environment as a result of the Cotonou Agreement with the European Union, the European Union–South Africa Free Trade Association, the U.S. African Growth and Opportunity Act, and World Trade Organization rules. The most direct effects of changes in the trade environment are to reduce tariff revenues going to the Government of Namibia and to reduce import prices faced by domestic producers and consumers. These effects are incorporated into our model. See Box 4.

The effects on output growth are more difficult to predict. In the short run, Namibia will face stiffer competition for its regional exports. In the longer run, a larger free-trade area could stimulate exports.

and 2.5% without them. Most of the increase in economic growth in the second decade of this century is due to the effects of lower tariffs.

There is a broader issue that we do not deal with in our model but that is important for Namibia's economic future. Changes in Namibia's trading arrangements are going to bring difficulties and well as benefits. Namibia's economy will be opened up to greater competition. By investing so much in education, the Government of Namibia has positioned the economy to make good use of the opportunities that freer trade will bring.

Main Finding (8): A Government Program to Provide HIV Medication Is Affordable

The pharmaceutical companies GlaxoSmithKlein, Bristol-Meyers Squibb, and Boerhinger Ingelheim have committed themselves to selling HIV medication to governments of developing countries at a price currently around US$1,100 per person-year. An Indian pharmaceutical company, Cipla Ltd., has offered the same medication for US$600 per person-year of coverage. These new lower prices have dramatically increased the ability of governments to finance the

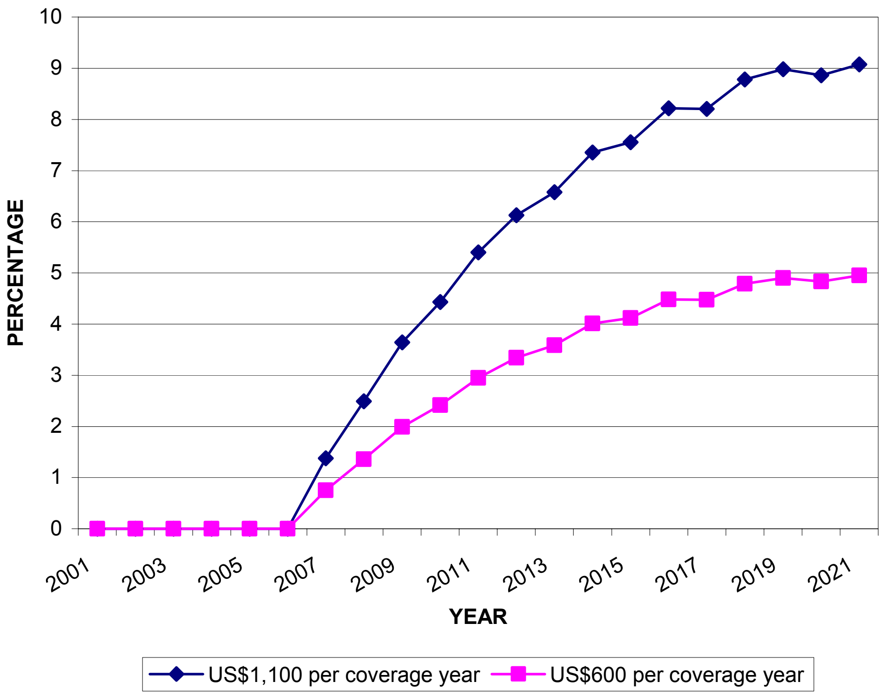

Figure 10. Cost of the FULL MEDICATION scenario as a percentage of the Government of Namibia's revenue.

provision of medication. Figure 10 shows the cost of medication as a percentage of the Government of Namibia's revenue for the FULL MEDICATION scenario using both the US$1,100 price and the US$600 price. Using the US$600 price, the FULL MEDICATION program never costs more that 5% of the Government's revenue.

The impact on government services of a 5% reduction in the Government's budget would be enormous, but this is not the only perspective from which to consider the cost of the medication. In 2021, the FULL MEDICATION program would cost about 1.3% of gross domestic product and it would increase GDP by about 1.5% compared with the CONTINUATION scenario. This suggests that the people of Namibia may be willing to increase their taxes in order to finance the FULL MEDICATION program.

The most important disadvantage of a FULL MEDICATION strategy is that it would reduce the incentive to adopt less risky behavior. We saw in Figure 2 that the population of Namibia under the FULL MEDICATION scenario was only somewhat higher than under the BEHAVIORAL CHANGE scenario. The cost of medication is only one component of an effective medical intervention program. At present, close physician monitoring is required for the medication to be used effectively. Namibia's medical infrastructure may not yet be able to handle the vastly increased demands placed upon it by the FULL MEDICATION scenario. Nevertheless, the people of Namibia can now afford to provide HIV medication to all those who can benefit from it. The question of whether or not to do so is no longer an economic one, but a political one. If the Government of Namibia pursues such a program, aiding Namibia's medical infrastructure should be a high priority for external donor organizations.

Main Finding (9): Unemployment Will Diminish

Namibia has a history of high unemployment and underemployment. This situation will improve in the next two decades. Our model assumes full employment for people with a secondary education or higher, but allows unemployment of people with primary education or lower. Figure 11 shows the employment of unskilled workers and the supply of those workers to all sectors, using 1991 age- and sex-specific labor force participation rates in the BEHAVIORAL CHANGE scenario. The two curves cross in 2012. In other words, in that year there would be full employment of all unskilled workers.

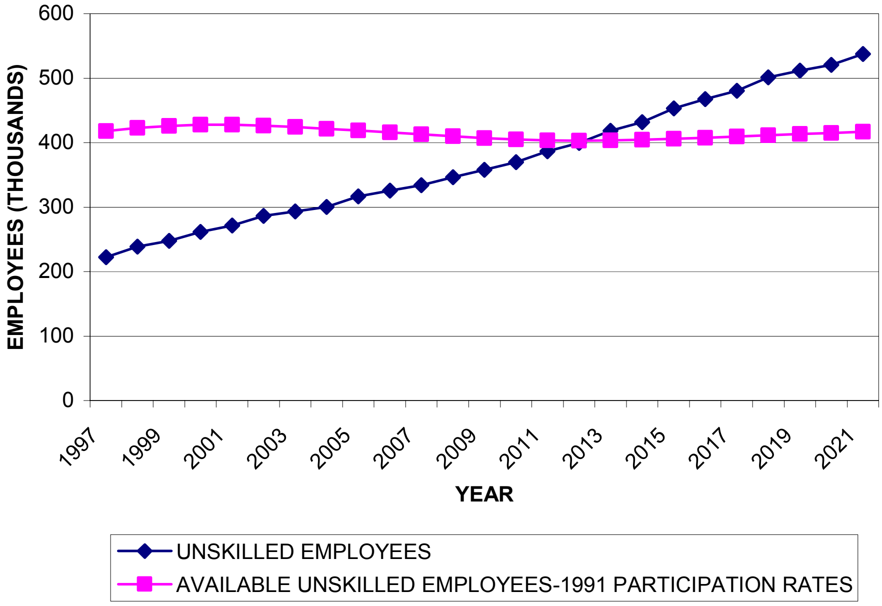

Figure 11. Employed unskilled workers and available unskilled workers assuming constant 1991 labor force participation rates according to the BEHAVIORAL CHANGE scenario.

This is, of course, improbable. The participation rates will rise and there will still be some unemployment. Nevertheless, by 2021 the supply at constant participation rates exceeds the demand by around 120,000 workers. The falling unemployment rate will gradually reduce the pressure on the Government to expand employment.

In the past, Namibia has taken in foreign skilled workers, in part to raise the rate of economic growth and provide jobs for its numerous unemployed. In the future, the situation will be different. The stock of domestic skilled workers will increase rapidly. More foreign skilled workers could still be brought in to increase the rate of economic growth, but this would tend to push unskilled wages up and bring about pressure for allowing more unskilled laborers to enter the country.

A great deal of the unemployment has been centered on the rural areas. Over the course of the next two decades, the population of the rural areas will shrink and unemployment will fall. This is good news for the rural areas. The bad news is that the population of those areas is increasingly likely to be composed of AIDS orphans and their elderly grandparents.

Main Finding (10): Water Stress Will Increase

To assess water stress, we divided Namibia into three Socio-Ecological Regions (SERs) (see Figure 12) based on the existing demographic and hydrologic characteristics of the country. SER1 encompasses the northern districts: Omusati, Oshana, Oshikoto, Ohangwena, Kavango, and Caprivi. This district covers an approximate area of 148,170 km^2, or about 18% of the total land area of Namibia, and contains 60% of the total population. SER2 is Windhoek and its surroundings. This region corresponds exactly to the province of Khomas and covers an area of roughly 37,080 km^2, or about 4% of the total land area of Namibia. About 12% of the population lives in SER2. Finally, SER3

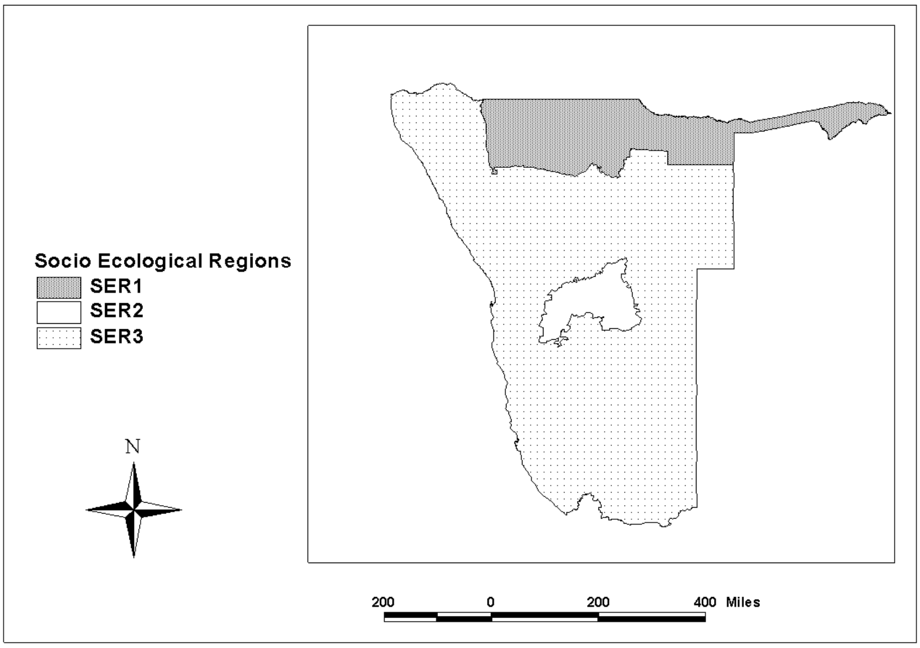

Figure 12. Socio-Ecological Regions of Namibia.

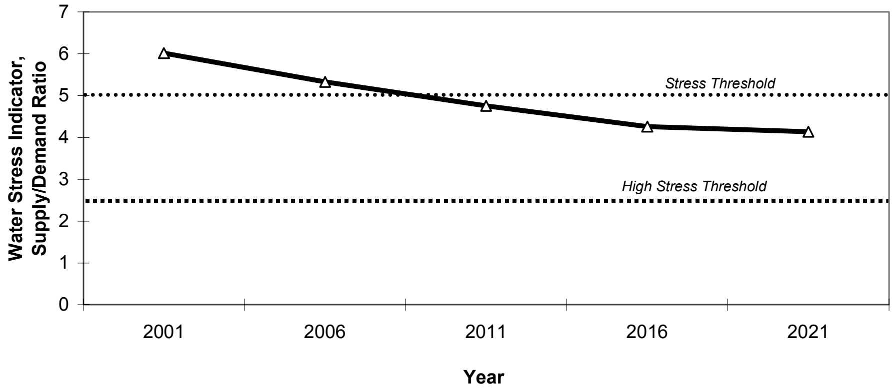

Figure 13. Supply/demand ratio over time, SER1: CONTINUATION scenario. Average of 30 climate runs, no global climate change.

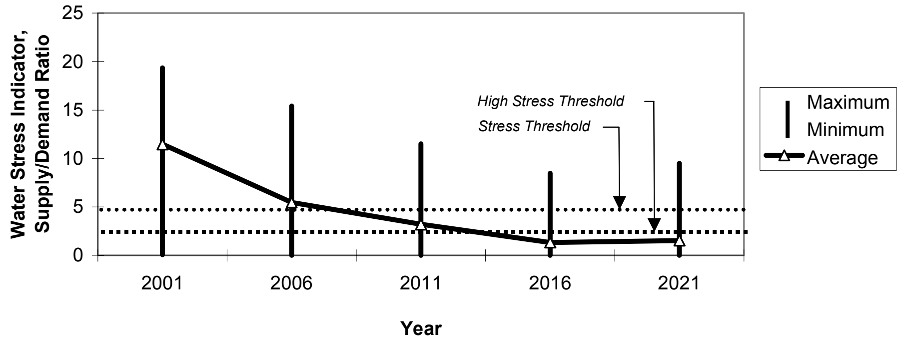

Figure 14. Supply/demand ratio over time, SER2: CONTINUATION scenario. Maximum, minimum, and average of 30 climate runs, no global climate change.

encompasses the Kunene, Otjizondjupa, Omaheke, Erongo, Hardap, and Karas administrative districts, covering about 640,570 km^2, or about 78% of the area of Namibia. This region contains approximately 28% of the population.

Figures 13 and 14 show the supply/demand ratio over time for SERs 1 and 2 for each of the 30 generated climates for the CONTINUATION scenario (see Boxes 10 and 11). The design of the model (see Box 9) is not appropriate for SER3. In both SERs there is an increase in level of water stress as we approach 2021. This is mainly the result of the increase in water demand caused by population growth, urbanization, and industrialization.

Box 9. The Namibia SER Water Resources Model.

We have constructed a detailed model of Namibia's water supply and demand. It is designed to provide forecasts of future regional water supply and demand for Namibia in order to determine the sustainability of the water supply under various forecasts of economic, population, and climate changes. The model produces probabilistic forecasts of available water supplies depending on the quantity and timing of rainfall. The water resources are modeled at both the Socio-Ecological Region (SER) scale and the Windhoek case study scale. The model uses a monthly time step to incorporate the seasonality of the basin hydrology. The modeled runoff of each basin is distributed to each SER depending on the water resources infrastructure. The initial water demand data were taken from the 1997 Water Transfer Consultants report. Data on river basin flows, precipitation, groundwater, and infrastructure were taken primarily from the Department of Water Affairs, the Central Area Water Master Plan, ALCOM Fisheries, the Links Dataset, and the National Center for Atmospheric Research (USA). Soil moisture data were derived from the Dunne dataset. The model assumes that water infrastructure currently being built will be completed.

Box 10. Water stress indicator.

The supply/demand ratio serves as a proxy for average water-related stress on both ecosystems and socioeconomic systems. Average annual supplies include groundwater recharge and total usable surface supply. Inflows include both domestic resources and inflows from other countries. The demands stem from various sectors: energy, institutions, industry, mining, agriculture, and livestock.

Four classes are defined: no stress, low stress, stress, and high stress. Several literature sources indicate that at ratios less than 5, water stress can become a limiting factor on economic development.

	No stress	Low stress	Stress	High stress
Supply/demand ratio	greater than 10	5 to 10	2.5 to 5	less than 2.5

Box 11. Stochastic modeling of water resources systems.

When modeling water storage systems, the sequence of floods and droughts is key to system performance. The vulnerability of a socioeconomic system to droughts and floods depends on its level of development. The time at which a drought occurs in the future could dramatically affect the impact felt by the economy and society. Since the exact values and sequence of future monthly rainfall quantities are uncertain, an ensemble of monthly climate variables was generated using stochastic generation techniques. For each climate scenario, 30 different climates for 20 years were generated and run through the model, yielding probabilistic future water supplies. These climate series were produced by the Stochastic Analysis and Modeling System (SAMS) model and preserve the patterns of rainfall over time and across regions.

These results indicate a modest increase in water stress in the northern SER1. This region of Namibia is relatively water abundant. Year-to-year rainfall changes do not matter in SER1. There is always as much water available as the infrastructure can handle. Water stress occurs as a result of the limits of the existing infrastructure. The probability of water stress is higher in SER2, the central region of Namibia. There water stress increases rapidly. Looking over all five population scenarios, there is around an 80% probability that 2021 will be a year of high water stress.

Main Finding (11): Current Trends Imply Rapid Increase in Windhoek's Water Stress

Figure 15 shows Windhoek and the pertinent infrastructure and supply nodes included in the analysis. Figure 16 shows Windhoek's water stress over time in the BEHAVIORAL CHANGE scenario (see Box 12). Water stress increases rapidly. There is around an 83% chance that 2021 will be a year of high water stress.

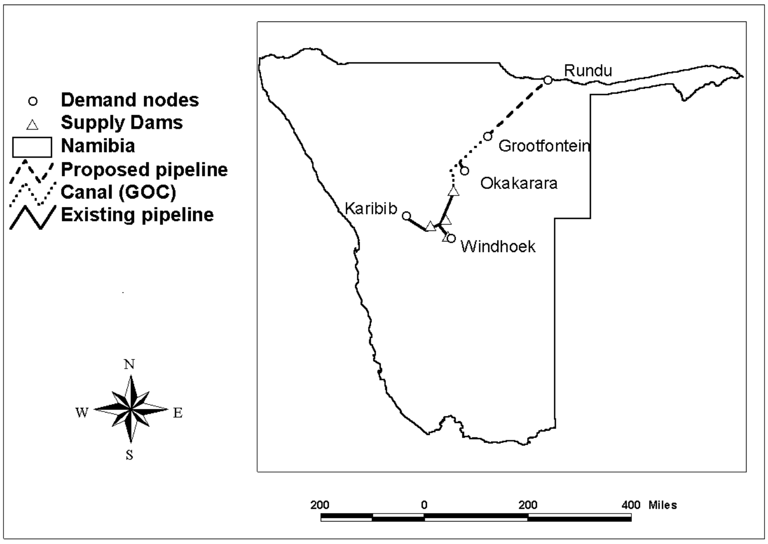

Figure 15. Windhoek surface water supply infrastructure.

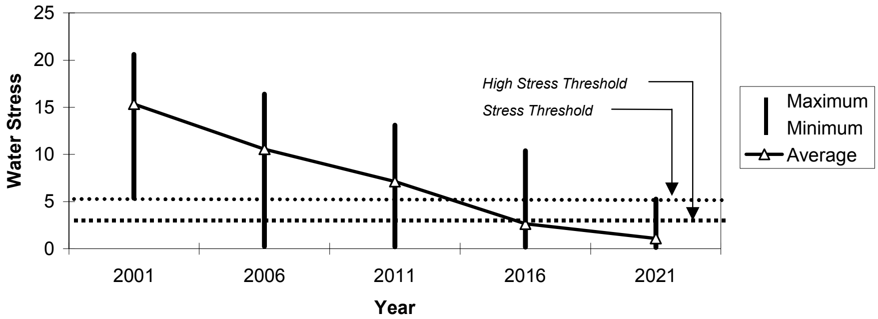

Figure 16. Water stress in Windhoek: BEHAVIORAL CHANGE scenario. Maximum, minimum, and average of 30 climate runs, no global climate change.

Box 12. Modeling Windhoek's water supply.

Windhoek's water supply was modeled using information on the existing water resources infrastructure. Currently the city receives its water from three major dams: Swakoppoort, Omatako, and Von Bach. These dams are all subject to extremely high rates of evaporation. In addition, Windhoek is supplied by the Windhoek aquifer and the Goreangab reclamation plant. A sustainable extraction rate for Windhoek aquifer of 2 million cubic meters per year was used for this analysis. Additionally, reclaimed water supply is assumed to increase from 5 million cubic meters per year in 2001 to 7.5 million cubic meters per year in 2011. Water transfers are governed by certain rules. The amount of water transferred to the Von Bach Dam from the Swakoppoort and Omatako Dams varies depending on their respective storage levels and transfer capacities. Water is transferred from the Swakoppoort and Omatako Dams to the Von Bach Dam to take advantage of the Von Bach Dam's better storage-to-evaporation characteristics (less evaporation for the amount of water). Transfer of water from the Swakoppoort Dam increases from the current rate of 4 million cubic meters per year to 10 million cubic meters per year in 2002.

Main Finding (12): Withdrawals from Kavango River Unnecessary

Figure 17 shows water stress in Windhoek in the BEHAVIORAL CHANGE scenario assuming additional water conservation. Domestic water use rates per capita are held at their 2001 levels and non-domestic water use rates are assumed to decrease gradually to 80% of their 2001 levels by 2021. The probability that 2021 will be a year of high water stress falls from 83% to 7%.

There has been some discussion of extending the Eastern National Water Carrier (ENWC) to the Kavango River to provide water to Windhoek. Our simulations suggest that conservation along with other approaches such as artificially recharging the Windhoek aquifer and bringing groundwater from the northern aquifers would reduce water stress in Windhoek enough to make withdrawals from the Kavango River unnecessary.

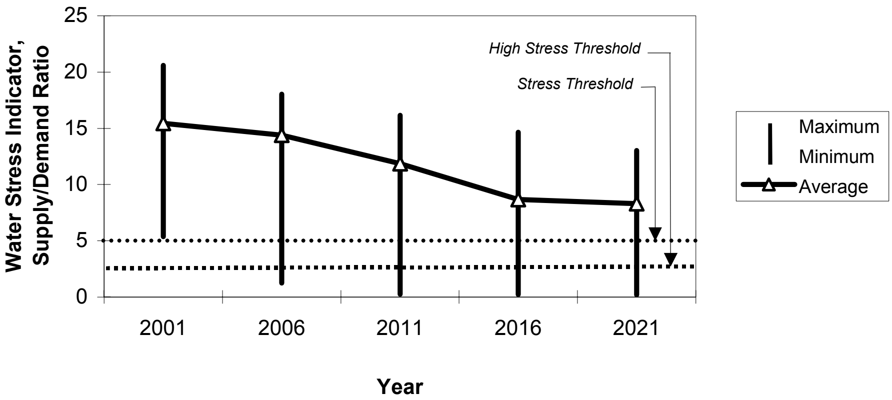

Figure 17. Water stress in Windhoek: BEHAVIORAL CHANGE scenario and a water conservation scenario. Maximum, minimum, and average of 30 climate runs, no global climate change.

Main Finding (13): Global Climate Change Uncertainties

Global Circulation Models (GCMs) of the Earth's climate show inconsistent changes for Namibia over the next two decades. We took predicted monthly rainfall and temperatures from three well-known GCMs and ran them through the Namibia SER Water Resources Model. We compared the outcomes to the previously computed figures, assuming no climate change. The implications of global climate change ranged from a very significant decrease in water stress to a very significant increase in water stress.

Even using the most optimistic global climate change model, there is a 72% probability that 2021 will be a year of high water stress in SER2 without additional conservation or water infrastructure. The other two models predict that the probability will be over 90%. This suggests that global climate changes are not going to be the answer to Namibia's water shortage. Given the possibility that global climate changes will reduce water supplies, it would be prudent to take precautions now. It takes a long time to implement conservation programs and to build pipelines and dams – about the same amount of time that it takes, in some GCMs, for significant additional water stress to occur.