

**SWAZILAND**

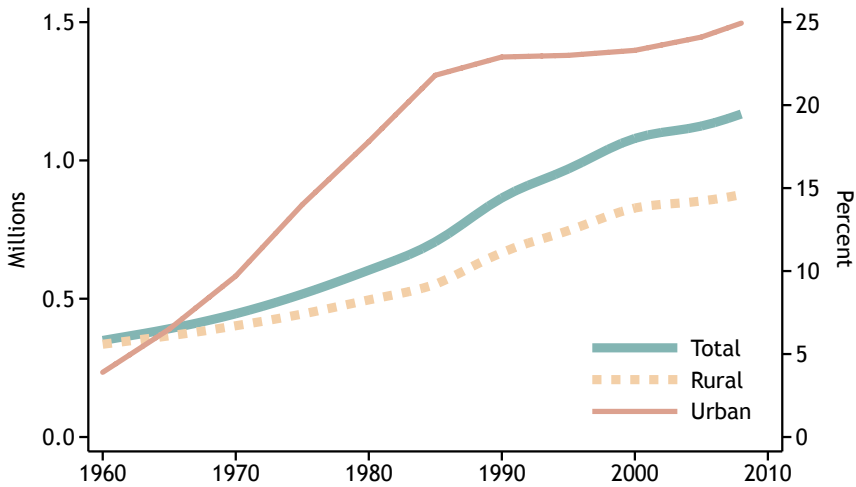
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**T**he Kingdom of Swaziland covers an area of 17,364 square kilometers bordered on the north, west, and south by the Republic of South Africa and on the east by Mozambique. The two major towns or cities are Mbabane, the capital city, and Manzini. The 2007 census put the population at 1.02 million, including 0.54 million females and 0.48 million males. About 78 percent live in rural areas and 22 percent in urban areas (Swaziland, Ministry of Economic Planning and Development 2007).

The majority of the rural people in Swaziland depend on cash income for survival strategies. Rural agriculture is insufficient to meet all food needs, but agricultural production provides a vital supplement to other food sources as well as employment opportunities during peak agricultural seasons (such as for weeding and harvesting).

Figure 8.1 shows population trends over the past 50 years, with the urban population continuing to grow but at a slower pace than it did prior to 1985. Table 8.1 shows population growth rates over the past 60 years. The total population growth rate dropped dramatically, to 0.9 percent from the 1980–1989 high of 3.6 percent, in part due to the impact of the HIV/AIDS endemic, with an adult prevalence rate currently at 26 percent. The average population density of the country is 59 persons per square kilometer, unevenly distributed across the country, with higher density in the urban areas and very sparse population in rural areas (Figure 8.2). The HIV/AIDS pandemic, affecting mainly the productive sector of the population, has had an impact on agricultural production (CANGO 2007).

About 40 percent of the 1 million inhabitants faced acute food and water shortages in 2007, with more than 60 percent of the overall population limiting or reducing their meal portions (IRIN 2007b). The drought that has persisted in southern Africa since 2002 became significantly worse in 2007. The 2007 maize harvest was the worst on record at 26,000 tons—a 60 percent reduction from 2006, causing about 50 percent of the population to be in need of food assistance until the April 2008 harvest. The drought in Swaziland

**FIGURE 8.1** Population trends in Swaziland: Total population, rural population, and percent urban, 1960–2008

Source: *World Development Indicators* (World Bank 2009).

**TABLE 8.1** Population growth rates in Swaziland, 1960–2008 (percent)

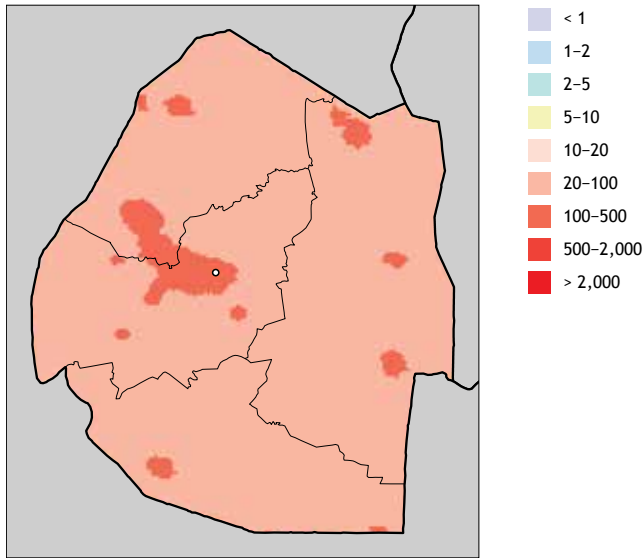
Decade	Total growth rate	Rural growth rate	Urban growth rate
1960–1969	2.4	1.8	11.6
1970–1979	3.0	2.1	9.2
1980–1989	3.6	2.9	6.4
1990–1999	2.3	2.2	2.4
2000–2008	0.9	0.7	1.7

Source: Authors' calculations based on *World Development Indicators* (World Bank 2009).

could have worsened the already severe HIV/AIDS situation, because patients on antiretroviral drugs may discontinue taking drugs in the absence of food (IRIN 2007b).

### Impacts of Climate Change to Date

The shortage of water for commerce and industry has affected the Swaziland textile industry, which employed more than 30,000 people but is now

**FIGURE 8.2** Population distribution in Swaziland, 2000 (persons per square kilometer)

Source: CIESIN et al. (2004).

struggling to operate due to persistent drought. Investors set up the textile industry after the government promised adequate water to run their operations. The investors threatened to pull out of the country if the government did not provide adequate water supplies (IRIN 2007b).

Bush encroachment and the invasion of alien plant species may become severe due to climate change. In the lowveld and lower middleveld of Swaziland, large portions of grazing lands have been invaded by *Dichrostachys cinerea*, reducing the grazing capacity. *Chromolaena odorata*, an alien invasive plant species, continues to spread through the subtropical regions of southern Africa, a development some researchers attribute to climate change (Kriticos, Yonow, and McFadyen 2005).

The purpose of this chapter is to help policymakers and researchers better understand and anticipate the likely impacts of climate change on agriculture and on vulnerable households in Swaziland. It is anticipated that the Swaziland Climate Change Programme, together with the national focal point on climate change, will use this chapter as a resource to raise awareness among stakeholders (farmers, policymakers, nongovernmental organizations, and others) regarding issues of climate change.

## Review of Current Trends

### Water Resources in Swaziland

Swaziland has annual renewable water resources of  $4,510 \times 10^6$  cubic meters, of which 42 percent originates in South Africa. Ten major dams store water used for irrigation, domestic, and industrial purposes, with a combined storage capacity of  $588.2 \times 10^6$  cubic meters (Mwendera et al. 2002).

The five main river systems are the Lomati, the Nkomati, the Mbuluzi, the Usuthu, and the Ngwavuma. The Komati and Lomati Rivers, located in the northern part of the country, both originate in South Africa and flow out of Swaziland back into South Africa before entering Mozambique. The Mbuluzi River arises in Swaziland and flows into Mozambique. The Usuthu River, along with a number of major tributaries, originates in South Africa and flows into Mozambique, forming the border between Mozambique and South Africa. The Ngwavuma River, located in the south, arises in Swaziland and flows into South Africa before entering Mozambique. A sixth river system contributes to surface water: the Pongola River, located on the southern border with South Africa. The Jozini Dam, constructed on the South African side of the river, flooded some land in Swaziland; as compensation, an agreement was reached between the two governments to make available to Swaziland some of the water from the dam.

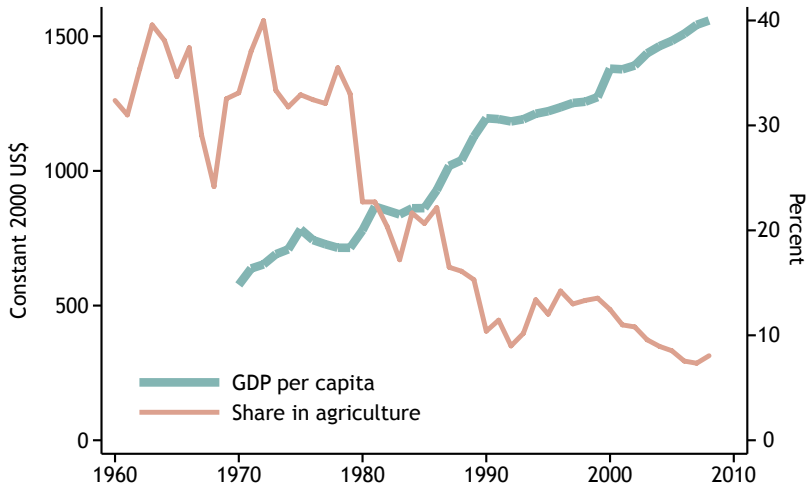
More than 95 percent of Swaziland's water resources are used for irrigation; only 1.2 percent are used for livestock, 2.3 percent for domestic uses, and 1.2 percent for industry (Knight Piesold 1997).

### Income and Financial Indicators

Swaziland is rated as a middle-income developing country, with per capita gross domestic product (GDP) (in constant 2000 US dollars) of \$1,560 in 2010. In recent years, per capita GDP has been increasing. At the same time, the share of agriculture in GDP has fallen, from an average of around 32 percent in 1970 to about 8 percent in 2008 (Figure 8.3). The real GDP growth rate was estimated at 2.0 percent in 2010, up from 1.2 percent in 2009. The agricultural sector grew by 3 percent in 2010 due to favorable weather conditions and better distribution of rainfall, which resulted in higher maize and cotton yields (Central Bank of Swaziland 2011). In 2010 the GDP composition by sector for agriculture, industry, and services was 7.4 percent, 49.2 percent, and 43.4 percent, respectively (CIA 2011).

Although the official unemployment rate is 28.2 percent (Swaziland, Ministry of Economic Planning and Development 2007), the actual figure is estimated at 40 percent, even higher in rural areas. Factors contributing to high

**FIGURE 8.3** Per capita GDP in Swaziland (constant 2000 US\$) and share of GDP from agriculture (percent), 1960–2008



Source: *World Development Indicators* (World Bank 2009).

Note: GDP = gross domestic product; US\$ = US dollars.

unemployment are the closure of major manufacturing companies in urban areas and the retrenchment from South African mines. The inflation rate slowed to about 3.5 percent in August 2010. Swaziland's currency (lilangeni) is pegged to the South African rand, subsuming Swaziland's monetary policy to South Africa's. Customs duties coming from the South African Customs Union (SACU) have contributed as much as 70 percent of government revenue over the years. However, the revenue share for Swaziland from SACU dropped by 62 percent in 2010, resulting in heavy budget cuts and growing government deficits (SACU 2010). Swaziland's economy grew by 2.4 percent in 2008 before declining to about 0.4 percent in 2009 (African Economic Outlook 2010)—far short of the government's target of 5 percent, which is required to reduce the poverty rate from 69 percent to 30 percent by 2015 in accord with the United Nations (UN) Millennium Development Goals.

#### **Well-being Indicators in Swaziland**

Maize is the staple foodcrop of Swaziland and is often used as an index of the availability of food in the country. Maize production showed a declining trend from 2004/2005 to 2006/2007, with some improvement in 2008/2009 (Figure 8.4). Swaziland is a net importer of maize, wheat, dairy products,

**FIGURE 8.4** Maize production in Swaziland, 2004/2005–2009/2010

Source: Swaziland, Ministry of Economic Planning and Development (2010).

and other agricultural products; it normally imports some 60 percent of the food consumed in the country. With the exception of wheat, almost all food imports come from South Africa. In 2010/2011, the total maize requirement was estimated at 166,000 tons, whereas domestic production was estimated at 82,000 tons, requiring the country to import about 50 percent of its requirement (Swaziland News Stories 2010).

About 69 percent of the total population lives below the poverty line of \$1 per day. The distribution of wealth and income is very skewed: the highest 10 percent of income earners garner 41 percent of the national income, and the lowest 10 percent of income earners garner just 1.6 percent of the national income (CIA 2011). About 40 percent of the population was faced with acute food and water shortages in 2007, when the prolonged drought caused the worst harvest in the country's recorded history (IRIN 2007a). About 18 percent of the population fell below the minimum dietary energy requirement of 2,100 kilocalories (IRIN 2007a). According to figures from 2000 (long before the 2007 food crisis), about 9 percent of the children under five years of age were malnourished in 2000.

Table 8.2 shows education and labor statistics for Swaziland in various periods. The government introduced free primary education in 2010 for grades 1 and 2 of the seven primary grades. Free education will be extended to an additional grade each year, covering all seven grades by 2015. This is expected to result in increased school enrollment at all levels and ultimately to improve the adult literacy rate, which stood at 81.6 percent in 2010. The government

**TABLE 8.2** Education and labor statistics for Swaziland, 2000s

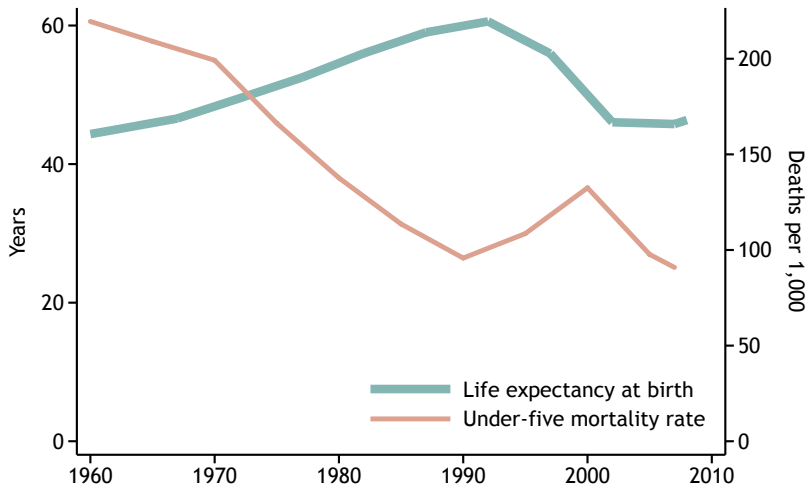
Indicator	Year	Value (percent)
Primary school enrollment (percent) <sup>a</sup>	2009	83.0
Secondary school enrollment (percent) <sup>a</sup>	2009	56.0
Adult literacy rate (percent) <sup>b</sup>	2010	81.6
Percent of active population employed in agriculture, both subsistence agriculture (informal) and commercial agriculture (formal) <sup>c</sup>	2008	70.0
Under-five malnutrition (percent) <sup>a</sup>	2010	9.1

Sources: <sup>a</sup>UNICEF (2011); <sup>b</sup>CIA (2011); <sup>c</sup>How We Made It in Africa (2010).

pays the school fees of orphaned and vulnerable children (OVCs) at all levels; there were about 120,000 registered OVCs in the country in 2010.

The agriculture sector (both subsistence and commercial) employs about 70 percent of the labor force. However, agriculture contributed only about 7.4 percent of GDP in 2010, because the economy has shifted to producing coal, wood pulp, sugar, drink concentrates, textiles and apparel, and other manufactured goods.

Figure 8.5 shows that life expectancy in Swaziland has declined over the past two decades, from 60 years in 1990 to just 45 years in 2005, driven

**FIGURE 8.5** Well-being indicators in Swaziland, 1960–2008

Source: World Bank (2009).

by the high prevalence of HIV/AIDS in addition to the impacts of poverty. The under-five mortality rate declined from 220 per 1,000 in 1960 to 100 per 1,000 in 1990; although the impacts of HIV/AIDS and poverty produced an increase through 2000, the rate has declined over the past decade to 90 per 1,000, due partly to the availability of antiretroviral drugs and increased awareness of HIV and AIDS, leading to changes in behavior (CANGO 2007).

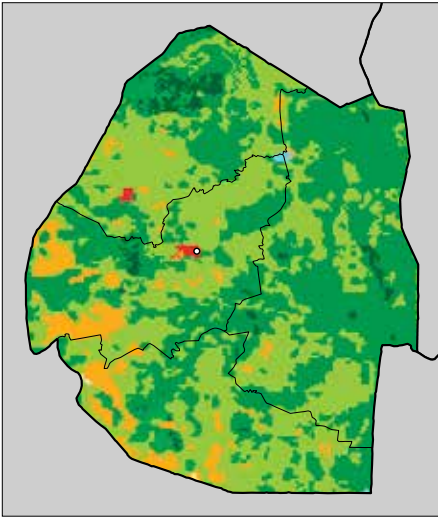
### **Land Use Overview**

Two major systems of land tenure exist in Swaziland. Title deed land (TDL) is privately owned land used mainly for ranching, forestry, or the estate production of such crops as vegetables, sugarcane, citrus, and pineapples; TDL covers 46 percent of the country. Swazi Nation land (SNL) is land held in trust by the king for the Swazi people, comprising 54 percent of the country. The average farm holding of cultivated land (SNL) is 1.5 hectares, with the maize yield averaging 1.0 tons per hectare. The average household size is eight people (Swaziland, Ministry of Works 2000).

The country is divided into four ecological zones based on elevation, landforms, geology, soil type, and vegetation. The highveld, middleveld, and lowveld each occupy about one-third of the country; the Lubombo Plateau occupies less than one-tenth. In the highveld, poor soils restrict agriculture to mainly grazing activities; only 3 percent of the region has good arable soils (Murdoch 1968). Almost 15 percent of the middleveld has arable soil of fair to good quality; about 20 percent of the lowveld has fair to good soils. Swaziland has a subtropical climate with summer rains (75 percent of all rainfall occurs in October–March). Climatic conditions range from subhumid and temperate in the highveld to semiarid in the lowveld. The long-term annual average rainfall figures for the highveld, middleveld, lowveld, and Lubombo Plateau are 950, 700, 475, and 700 millimeters, respectively (Swaziland, Ministry of Works 2000).

Swaziland has a total area of 1.7 million hectares. The main land use is extensive communal grazing, which covers about 50 percent of the area (SNL) (Figure 8.6 and Table 8.3). About 12 percent of the total area is used for small-scale crop production. Large-scale agriculture is practiced in 6 percent of the total area (TDL), with about 70,000 hectares irrigated; the dominant crop under irrigation is sugarcane. Forest plantations cover about 8 percent of the total area (see Table 8.3) and parks, reserves, and hunting areas about 4 percent. Such areas are important for the protection of fragile environments as well as for the tourism industry, which contributes about 7 percent of the GDP.

**FIGURE 8.6** Land cover and land use in Swaziland, 2000



- Tree cover, broadleaved, evergreen
- Tree cover, broadleaved, deciduous, closed
- Tree cover, broadleaved, open
- Tree cover, broadleaved, needle-leaved, evergreen
- Tree cover, broadleaved, needle-leaved, deciduous
- Tree cover, broadleaved, mixed leaf type
- Tree cover, broadleaved, regularly flooded, fresh water
- Tree cover, broadleaved, regularly flooded, saline water
- Mosaic of tree cover/other natural vegetation
- Tree cover, burnt
- Shrub cover, closed-open, evergreen
- Shrub cover, closed-open, deciduous
- Herbaceous cover, closed-open
- Sparse herbaceous or sparse shrub cover
- Regularly flooded shrub or herbaceous cover
- Cultivated and managed areas
- Mosaic of cropland/tree cover/other natural vegetation
- Mosaic of cropland/shrub/grass cover
- Bare areas
- Water bodies
- Snow and ice
- Artificial surfaces and associated areas
- No data

Source: GLC2000 (Bartholome and Belward 2005).

**TABLE 8.3** Land use in each ecological zone of Swaziland, 1994

Land use type	Ecological zone													
	Highveld			Middleveld			Lowveld			Lubombo			Total	
	Hectares	Percent		Hectares	Percent		Hectares	Percent		Hectares	Percent		Hectares	Percent
Smallholder agriculture	39,100	6.9		74,000	15.4		84,200	15.1		16,100	10.9		213,400	12.3
Large-scale agriculture	1,100	0.2		18,400	3.8		81,400	16.9		2,800	1.9		103,700	6.0
Extensive communal grazing	320,600	56.7		291,000	60.3		173,800	30.5		80,400	54.3		865,800	50.0
Ranching	49,500	8.7		85,800	17.8		184,300	31.0		32,700	22.1		332,300	19.2
Forest plantations	132,300	23.4		7,500	1.6		0	0.0		0	0.0		139,800	8.1
Extraction and collection	0	0.0		0	0.0		8,400	1.3		0	0.0		8,400	0.5
Parks and reserves	20,100	3.5		900	0.4		21,100	4.7		16,100	10.9		58,200	3.4
Water reservoirs	400	0.1		0	0.0		3,800	0.7		0	0.0		4,200	0.2

Source: Rammelzwaal and Dlamini (1994).

Natural forests cover 36,556 hectares, while woodlands cover 382,261 hectares and bushlands or savannas cover 232,954 hectares (Menne and Carrere 2007). In Swaziland, plantations of black wattle (*Acacia mearnsii*) were first established in the early 1880s; the wood is used mainly for tanning in the leather industry. Wattle wood was used for mine props in local tin mines, which were thriving at that time, and later became widely used as building material and fuelwood. Subsequently, pine and eucalyptus trees were introduced as the main plantation species. The main pine species are *Pinus patula*, *Pinus radiate*, and *Pinus taeda*, covering about 80 percent of the planted area. The eucalyptus species are mainly *Eucalyptus saligna* and *Eucalyptus grandis*, covering 20 percent of the planted area.

About 22 percent of the population lives in urban areas, including the two main cities, Mbabane and Manzini, and 15 other towns. Manzini has a population of about 100,000 people, while Mbabane has a population of between 70,000 and 90,000. There are also some rural settlements with sizeable populations, mainly around police stations, mission schools, mining settlements, railway stations, and shopping centers.

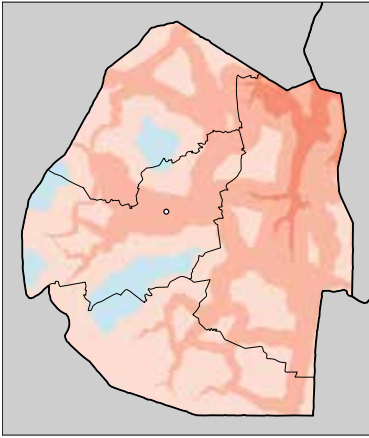
Figure 8.7 shows the travel times to urban areas of various sizes. The first panel of Figure 8.7 shows travel times to cities of 500,000 or more people (referring to cities outside the country, because there are no cities of that size in Swaziland). These urban areas provide potential markets for agricultural products. Manzini, the largest city, is strategically located in the center of the country. The travel time between Manzini and Mbabane, as well as to several other urban areas, is less than one hour due to good road networks. For some remote areas that still have no roads, however, the travel time to the nearest town is five hours or more. Such areas tend to be underdeveloped and impoverished, with very little means of livelihood.

### **Agriculture Overview**

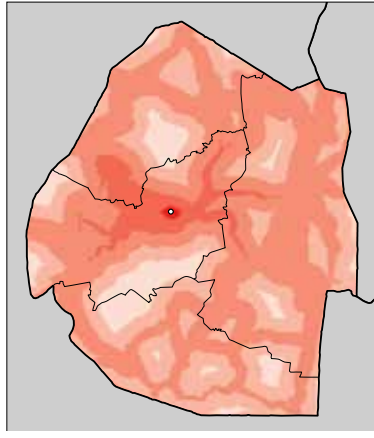
Although 80 percent of the rural population is engaged in agriculture, almost all households rely on additional sources to meet their total food requirement. This chapter focuses on field and plantation crops, but livestock is also a significant sector, with 585,000 head of cattle, 276,000 goats, and 28,000 sheep counted in 2008 (FAO 2010).

About 95 percent of the water resources are used for irrigation, with sugarcane using over 84 percent of the irrigation water. Sugarcane is planted on about 53,000 hectares, exclusively under irrigation. It is grown mainly in

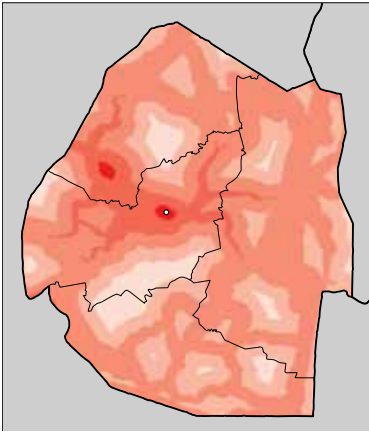
**FIGURE 8.7** Travel time to urban areas of various sizes in Swaziland, circa 2000



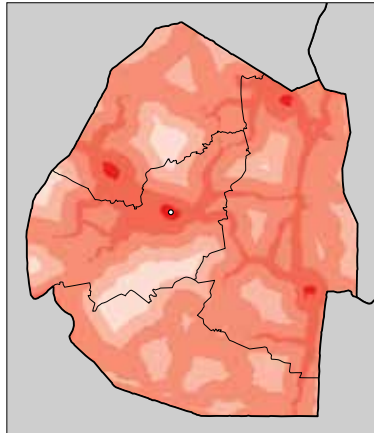
To cities of 500,000 or more people



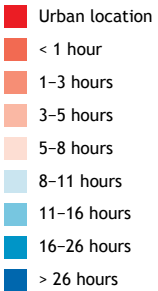
To cities of 100,000 or more people



To towns and cities of 25,000 or more people



To towns and cities of 10,000 or more people



Source: Authors' calculations.

the lowveld but is increasingly being grown in the lower middleveld. The Swaziland Sugar Association (SSA), the umbrella organization for growers and millers of sugarcane, provides technical services (SSA 2010). The total cane production was 4,912,949 tons in 2008/2009 and 4,908,152 tons in 2009/2010. About 500 small-scale growers have emerged since the 1990s. The Swaziland Water and Agricultural Development Enterprise (SWADE), a government-owned company, plays a major role in promoting smallholder farmers' participation in the sugarcane industry; it facilitates the implementation of the Komati Downstream Development Project and the Lower Usuthu Smallholder Irrigation Project (LUSIP) (SWADE 2010). The sugarcane industry directly employs about 16,000 people, and another 20,000 people benefit from it indirectly (FAO 2005).

Maize is the staple food in Swaziland and is cultivated on about 47,000 hectares. The area planted in maize has been decreasing over time due to a number of factors, including the change from maize production to sugarcane production and the persistent drought and erratic rains, which have led to the abandonment of crop growing. In 1992/1993 the area under maize cultivation was 58,787 hectares (Swaziland, Ministry of Economic Planning and Development 1992). Predominantly rainfed, maize is especially vulnerable to droughts and other effects of climate change. The National Maize Corporation (NMC) is responsible for guaranteeing the availability of quality white maize all year, as well as for reducing the marketing barriers and costs to Swazi farmers and increasing the efficiency of the domestic maize market (NMC 2010). It facilitates setting a floor price for maize and controls imports and exports of the crop.

Like maize production, seed cotton production has declined over the past 15 years. In 1992/1993, about 26,600 hectares of land were under cotton production, declining to 3,000 hectares by 2008. The production of seed cotton is coordinated and promoted by the Swaziland Cotton Board, a public enterprise under the Ministry of Agriculture (Swaziland, Ministry of Agriculture 2010). Cotton is grown mainly in the lowveld because it is drought tolerant, and it is a substitute crop for maize in areas with low rainfall.

Citrus fruits (oranges and grapefruits) are grown mainly for canning and juice extraction at the Swaziland Fruit canning factory in Malkerns. Other crops, such as groundnuts, beans, and cowpeas, are grown on a small scale, often intercropped with maize. Table 8.4 shows key agricultural crops in terms of area harvested; Table 8.5 shows key agricultural commodities in terms of their consumption.

**TABLE 8.4** Area and production of different crops in Swaziland, 2006–2008

Rank	Crop	Harvest area (thousands of hectares)	Total production (metric tons)
1	Sugarcane	53	5,000,000
2	Maize	47	60,765
3	Seed cotton	15	1,115
4	Roots and tubers	7	51,696
5	Oranges	7	38,960
6	Groundnuts	6	3,699
7	Grapefruits (including pomelos)	4	33,008
8	Beans	4	4,958
9	Potatoes	3	5,057
10	Pineapples	1	16,841
11	Cowpeas	2	769
12	Sweet potatoes	1	3,068

Source: FAOSTAT (FAO 2010).

Note: All values are based on a three-year average for 2006–2008.

**TABLE 8.5** Consumption of leading food commodities in Swaziland, 2003–2005 (thousands of metric tons)

Rank	Crop	Percent of total	Food consumption
	Total	100.0	486
1	Maize	15.2	74
2	Fermented beverages	11.0	53
3	Roots and tubers	8.6	42
4	Wheat	8.4	41
5	Sugar	6.5	31
6	Beef	5.4	26
7	Grapefruits	4.7	23
8	Beer	4.3	21
9	Other fruits	4.2	20
10	Other vegetables	4.0	20

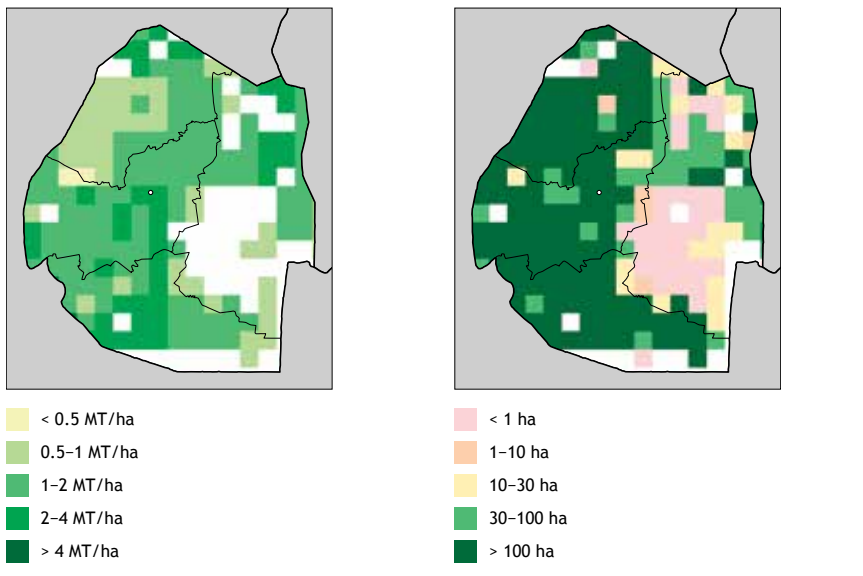
Source: FAOSTAT (FAO 2010).

Note: All values are based on a three-year average from 2003–2005.

Maize is the leading food commodity consumed in the country, with more than 74,000 tons consumed annually. Second are fermented beverages made from maize and sorghum, including traditional beer (see Table 8.5). Virtually all the wheat consumed in the country is imported. The total sugar produced in the country in 2006–2008 was about 631,000 tons, with 31,000 tons consumed domestically and the rest (about 95 percent) exported. Fruits and vegetables are produced mainly on a small-scale basis, and most of the country's demand is met through imports. The National Agricultural Marketing Board (NAMBOARD) is responsible for promoting the production of fruits and vegetables as well as controlling their import (NAMBOARD 2010).

Maize is produced in all the ecological zones of Swaziland but mainly in the highveld and middleveld, because yields are very low in the lowveld; the average yield in the highveld and upper middleveld is about 2 tons per hectare (Figure 8.8). Nearly all maize production is rainfed, except that of “green maize,” which is produced by irrigation.

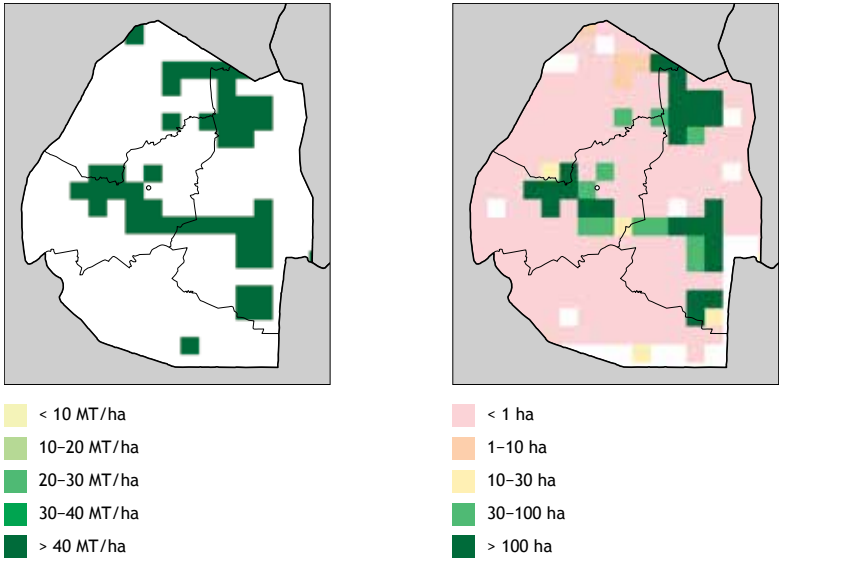
**FIGURE 8.8** Yield (metric tons per hectare) and harvest area density (hectares) for rainfed maize in Swaziland, 2000



Source: SPAM (Spatial Production Allocation Model) (You and Wood 2006; You, Wood, and Wood-Sichra 2006, 2009).

Note: ha = hectare; MT/ha = metric tons/hectare.

**FIGURE 8.9** Yield (metric tons per hectare) and harvest area density (hectares) for irrigated sugarcane in Swaziland, 2000



Source: SPAM (Spatial Production Allocation Model) (You and Wood 2006; You, Wood, and Wood-Sichra 2006, 2009).  
 Note: ha = hectare; MT/ha = metric tons/hectare.

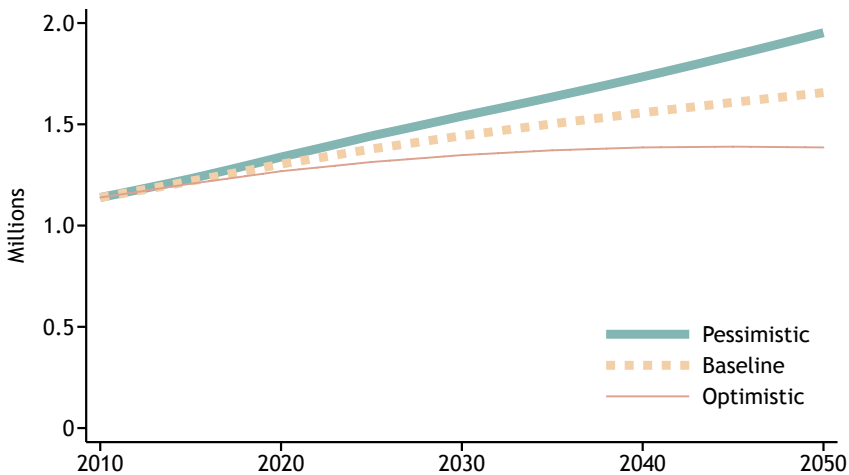
Sugarcane is grown predominantly under irrigation, with the average yield more than 90 tons per hectare. Rainfed sugarcane production is found in very small areas in the northern part of the country, where the average yield is more than 40 tons per hectare (Figure 8.9). Rainfed sugarcane tends to be grown by small-scale farmers on small plots of less than 1 hectare, with an average yield of less than 1 ton per hectare.

## Scenarios for the Future

### Economic and Demographic Indicators

#### Population

The high-variant population projection for Swaziland shows the population almost doubling by the year 2050. The low-variant projection shows the population increasing by about 25 percent by 2050, from 1.1 million to about 1.4 million; this variant assumes a continuing low rate of population growth (Figure 8.10). The medium variant shows the population increasing by around 50 percent by 2050. Any increase in population needs to be accompanied by

**FIGURE 8.10** Population projections for Swaziland, 2010–2050

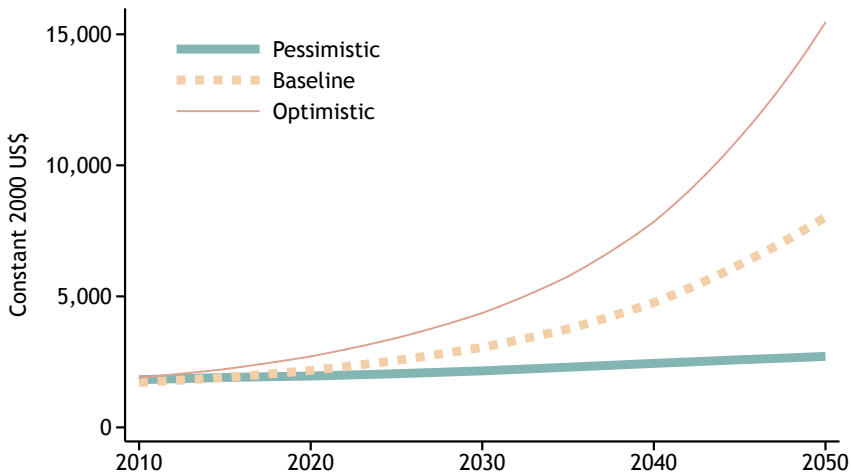
Source: UNPOP (2009).

economic gains, along with increased food production and additional facilities and infrastructure.

### Income

Figure 8.11 presents three overall scenarios for GDP per capita derived by combining three GDP scenarios with the three population scenarios of Figure 8.10 (based on UN population data). The optimistic scenario combines high GDP growth with low population growth, the baseline scenario combines medium GDP growth with medium population growth, and the pessimistic scenario combines low GDP growth with high population growth. (The agricultural modeling in the next section uses these scenarios as well.)

The pessimistic scenario shows a slow increase in GDP per capita, while the optimistic scenario shows a sharp increase in GDP per capita over time. The baseline scenario, showing a moderate increase in GDP per capita, is the likely scenario for Swaziland: annual economic growth is expected to be about 2.5 percent, with a moderate population increase. Current policies aimed at improving the economy include soliciting foreign direct investment by improving the country's infrastructure, including its road networks, railway service, telecommunications, and air travel. A new international airport is under construction at Sikhuphe and should be in operation in 2013.

**FIGURE 8.11** Gross domestic product (GDP) per capita in Swaziland, future scenarios, 2010–2050

Sources: Computed from GDP data from the World Bank Economic Adaptation to Climate Change project (World Bank 2010b), from the Millennium Ecosystem Assessment (2005) reports, and from population data from the United Nations (UNPOP 2009). Note: US\$ = US dollars.

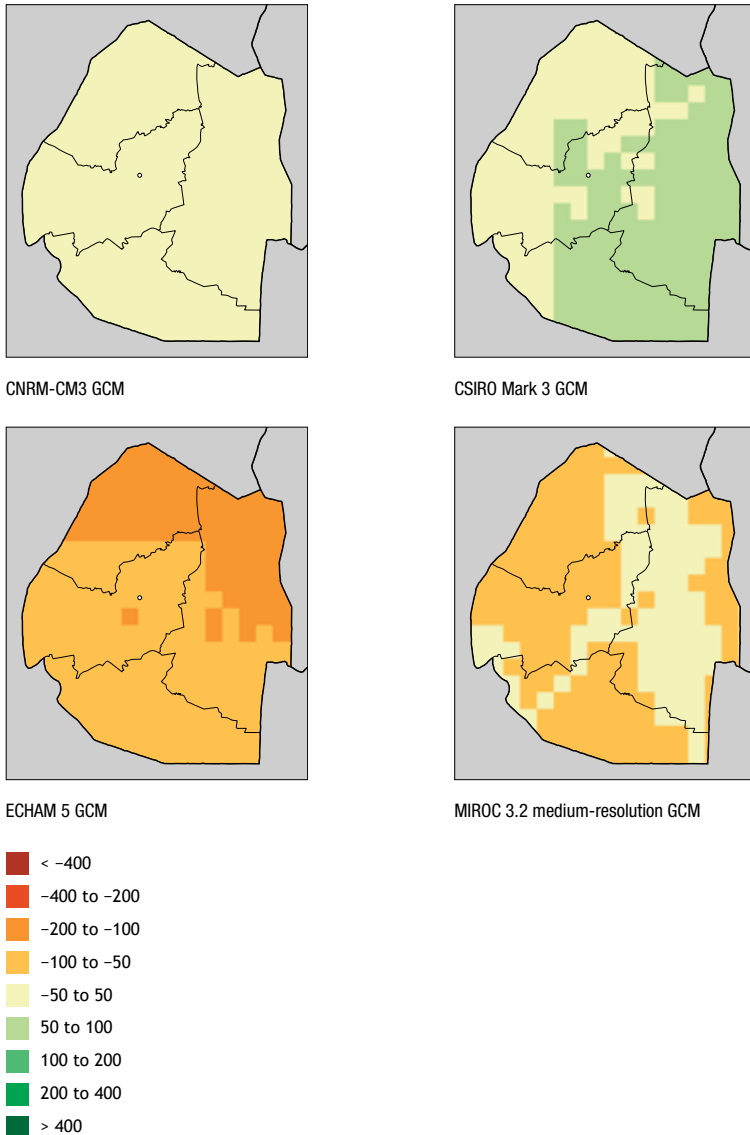
## Biophysical Analysis

### Climate models

Figure 8.12 shows projected precipitation changes for 2000–2050 under the four downscaled general circulation models (GCMs) we use in this monograph with the A1B scenario.<sup>1</sup> CNRM-CM3 shows an insignificant change in annual rainfall over the 50-year period (in the range of –50 to +50 mm). CSIRO Mark 3 shows no significant change in the northern and eastern parts of the country (mainly the highveld), and an annual increase of between 50 and 100 millimeters in the central and eastern parts of the country (the middleveld, lowveld, and Lubombo Plateau). Both ECHAM 5 and MIROC 3.2, however, show a decrease in annual precipitation over the same period (see Figure 8.12); ECHAM 5 shows an annual reduction

1 The A1B scenario describes a world of very rapid economic growth, low population growth, and rapid introduction of new and more efficient technologies with moderate resource use and a balanced use of technologies. CNRM-CM3 is National Meteorological Research Center–Climate Model 3. CSIRO is a climate model developed at the Australia Commonwealth Scientific and Industrial Research Organisation. ECHAM 5 is a fifth-generation climate model developed at the Max Planck Institute for Meteorology in Hamburg. MIROC is the Model for Interdisciplinary Research on Climate, developed at the University of Tokyo Center for Climate System Research.

**FIGURE 8.12** Change in mean annual precipitation in Swaziland, 2000–2050, A1B scenario (millimeters)



Source: Authors' calculations based on Jones, Thornton, and Heinke (2009).

Notes: A1B = greenhouse gas emissions scenario that assumes fast economic growth, a population that peaks midcentury, and the development of new and efficient technologies, along with a balanced use of energy sources; CNRM-CM3 = National Meteorological Research Center–Climate Model 3; CSIRO = climate model developed at the Australia Commonwealth Scientific and Industrial Research Organisation; ECHAM 5 = fifth-generation climate model developed at the Max Planck Institute for Meteorology (Hamburg); GCM = general circulation model; MIROC = Model for Interdisciplinary Research on Climate, developed by the University of Tokyo Center for Climate System Research.

of as much as 200 millimeters in the northern part of the country. That level of rainfall reduction would create some hardship and would require adaptive measures.

Figure 8.13 shows the change in the mean daily maximum temperature for the warmest month with the A1B scenario, according to the GCMs. All four GCMs show an increase in the annual maximum temperatures for Swaziland (see Figure 8.13). CNRM-CM3 shows an increase of between 1.5° and 2.0°C, whereas CSIRO Mark 3 shows an increase of between 1.0° and 1.5°C. ECHAM 5 shows the greatest increase: between 2.0° and 2.5°C for the western part of the country (highveld and middleveld) and between 1.5° and 2.0°C for the eastern part (lowveld and Lubombo Plateau). MIROC 3.2 shows an increase of around 1.5°C for the entire country, with the “splotchy” pattern actually reflecting the fact that all values are very close to that figure, with some slightly higher and some slightly lower (see Figure 8.13).

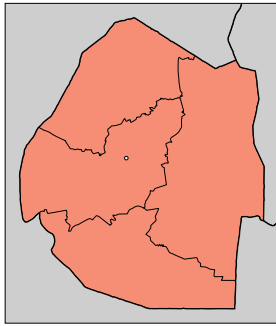
The potential impacts of climate change include changes in land cover; reduced rainfall and increased temperatures would likely mean an increase in shrubs and herbaceous cover and a reduction in tall tree cover. In planning adaptation and mitigation strategies for climate change, it is advisable to keep in mind the worst-case scenario, which might include an increase in temperature of between 2.0° and 2.5°C and a reduction in precipitation of 200 millimeters. However, investment to prepare for such an outcome would be premature until there are more indications that it will be realized.

### **Crop Models**

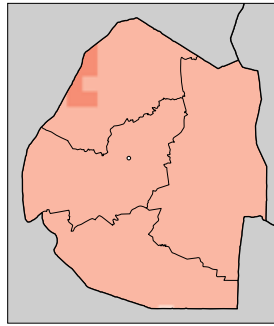
The Decision Support Software for Agrotechnology Transfer (DSSAT) crop modeling system was used to compare the modeled 2050 yield results (using the four GCMs) with the results for baseline yield (with unchanged climate).

The output for maize—the staple food—is mapped in Figure 8.14. The results from CNRM-CM3, CSIRO Mark 3, and MIROC 3.2 are similar, showing a reduction in maize yield of more than 25 percent of the baseline, as well as an increase in yield of more than 25 percent in some parts of the lowveld. The area shown with a yield loss of more than 25 percent is in the traditional maize-producing regions (the highveld), and it covers a larger area than that shown with a yield increase of more than 25 percent (the lowveld). This result indicates that the overall maize production would be reduced under both CNRM-CM3 and CSIRO Mark 3. ECHAM 5 also shows an overall yield loss of more than 25 percent of baseline for most of the country.

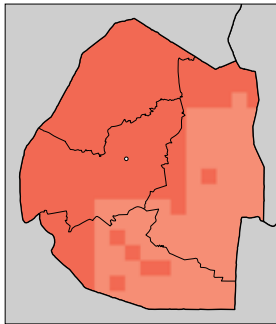
**FIGURE 8.13** Change in monthly mean maximum daily temperature in Swaziland for the warmest month, 2000–2050, A1B scenario (°C)



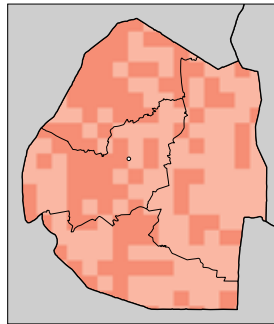
CNRM-CM3 GCM



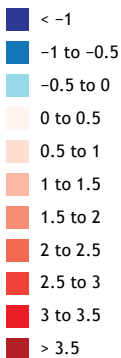
CSIRO Mark 3 GCM



ECHAM 5 GCM



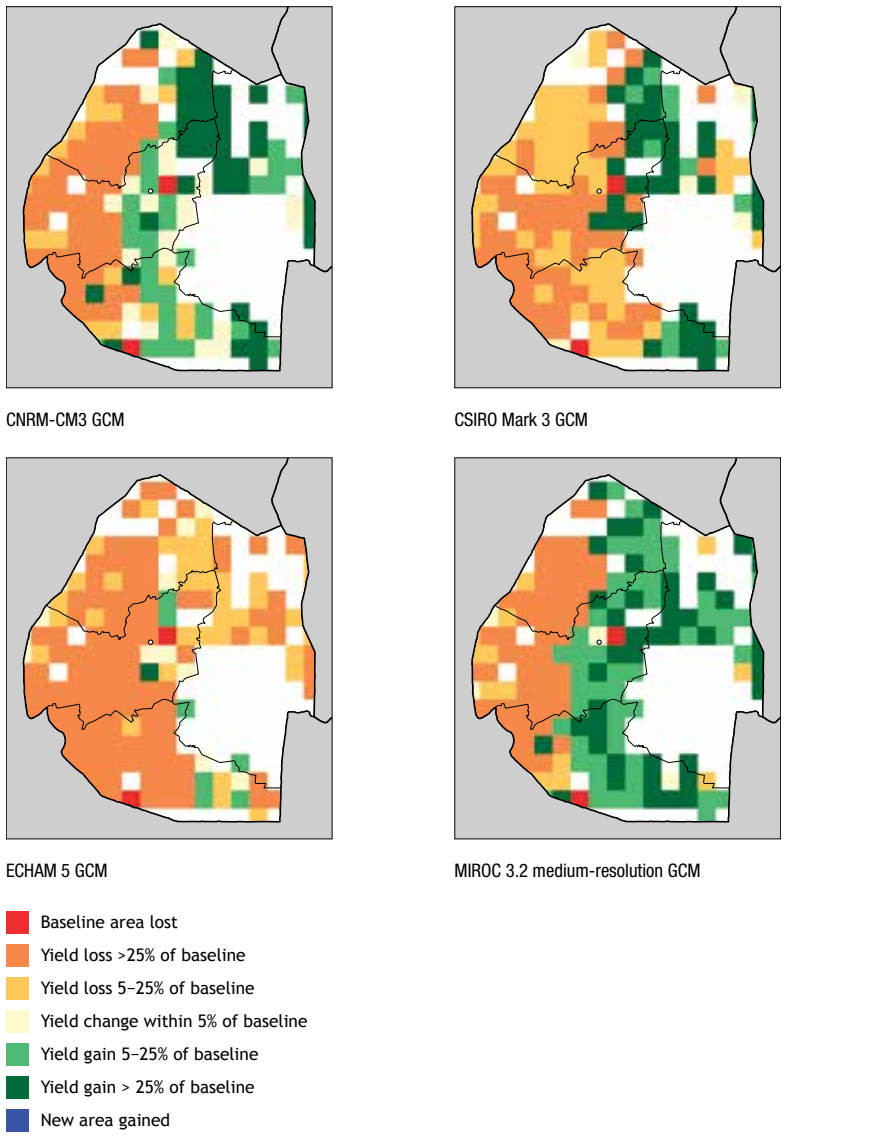
MIROC 3.2 medium-resolution GCM



Source: Authors' calculations based on Jones, Thornton, and Heinke (2009).

Notes: A1B = greenhouse gas emissions scenario that assumes fast economic growth, a population that peaks midcentury, and the development of new and efficient technologies, along with a balanced use of energy sources; CNRM-CM3 = National Meteorological Research Center–Climate Model 3; CSIRO = climate model developed at the Australia Commonwealth Scientific and Industrial Research Organisation; ECHAM 5 = fifth-generation climate model developed at the Max Planck Institute for Meteorology (Hamburg); GCM = general circulation model; MIROC = Model for Interdisciplinary Research on Climate, developed by the University of Tokyo Center for Climate System Research.

**FIGURE 8.14** Yield change under climate change: Rainfed maize in Swaziland, 2000–2050, A1B scenario



Source: Authors' calculations.

Notes: A1B = greenhouse gas emissions scenario that assumes fast economic growth, a population that peaks midcentury, and the development of new and efficient technologies, along with a balanced use of energy sources; CNRM-CM3 = National Meteorological Research Center–Climate Model 3; CSIRO = climate model developed at the Australia Commonwealth Scientific and Industrial Research Organisation; ECHAM 5 = fifth-generation climate model developed at the Max Planck Institute for Meteorology (Hamburg); GCM = general circulation model; MIROC = Model for Interdisciplinary Research on Climate, developed by the University of Tokyo Center for Climate System Research.

Note that the baseline yield for the lowveld is lower than that for the highveld, and the latter is shown with a yield loss of 25 percent or more in *all* the models. Nevertheless, in all but the ECHAM 5 model, we see substantial areas with a yield increase of more than 25 percent under climate change. This means that there may be opportunities to adapt to climate change at the national level by shifting maize production over time to areas that are becoming more productive as a result of the change.

### **Agricultural Outcomes**

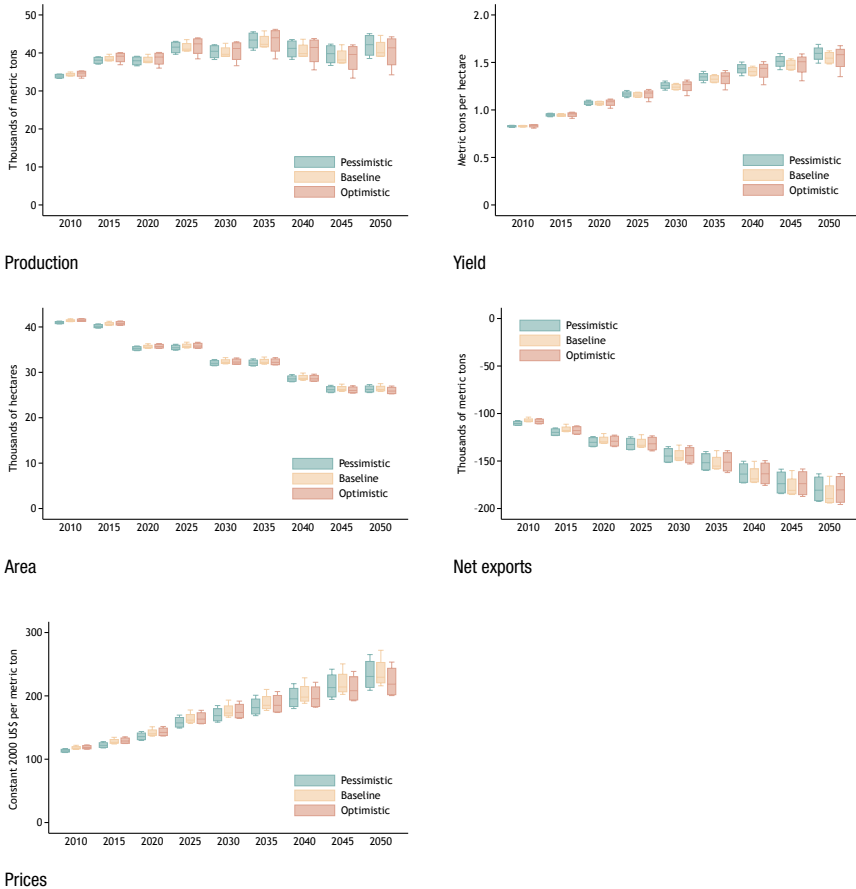
Figures 8.15–8.17 show simulation results from the International Model for Policy Analysis of Agricultural Commodities and Trade (IMPACT) associated with maize, sugarcane, and cotton, respectively. Each featured crop has five graphs: production, yield, area, net exports, and world prices. The simulations included the three GDP and population scenarios and the GCMs.

The production of maize is expected to increase over time in all scenarios but not enough to meet domestic demand, currently at 150,000 tons per year. This is reflected in anticipated increased imports of maize (shown as a decrease in net exports in Figure 8.15). By 2050, the country is shown importing nearly 200,000 tons of maize. With the world price of maize shown to be increasing from \$120 to about \$250 per ton, maize could become unaffordable for the majority of the population if the pessimistic scenario comes to pass.

The harvested area of maize is shown to decrease over time in all scenarios, whereas the average yield is shown to increase, from 1.0 tons per hectare to about 1.5 tons per hectare by 2050. Hybrid maize seeds, already available in Swaziland, can produce as much as 10 tons per hectare under good management and agronomic conditions. Several programs have been initiated to increase production, including the Comprehensive African Agricultural Development Program (CAADP), the Swaziland Agricultural Development Program (SADP), and the Tractor Hire Pool program of the Ministry of Agriculture (discussed below).

Sugarcane is produced mainly for export; less than 5 percent of the sugar produced is consumed locally. Production of sugarcane is expected to increase to about 17,000 tons by 2050 (see Figure 8.16). The industry receives technical and agronomic support from organizations such as the Swaziland Sugar Association and SWADE. The area planted with sugarcane is expected to increase to more than 80,000 hectares by 2050. Only 11 percent of the area in Swaziland is considered arable, and not all of that is suitable for irrigation, which is generally required for sugarcane. Land is already being converted to

**FIGURE 8.15** Impact of changes in GDP and population on maize in Swaziland, 2010–2050

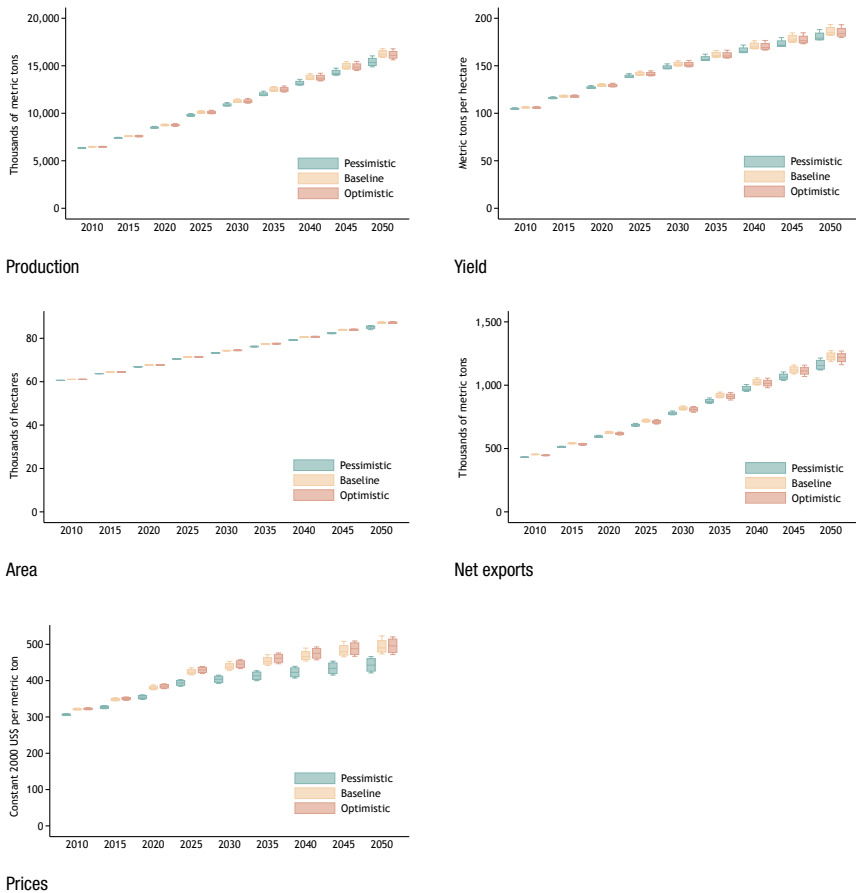


Source: Based on analysis conducted for Nelson et al. (2010).

Notes: The box and whiskers plot for each socioeconomic scenario shows the range of effects from the four future climate scenarios. GDP = gross domestic product; US\$ = US dollars.

sugarcane production from other uses, such as grazing, growing cotton, and subsistence maize farming. The net export of sugar is expected to triple by 2050, bringing much-needed foreign currency (see Figure 8.16). The sugar processing industry is diversifying to producing ethanol from molasses and generating electricity from byproducts as a way to offset fluctuations in the world price of sugar. Generating electricity would also reduce the operation costs of the industry.

**FIGURE 8.16** Impact of changes in GDP and population on sugarcane in Swaziland, 2010–2050

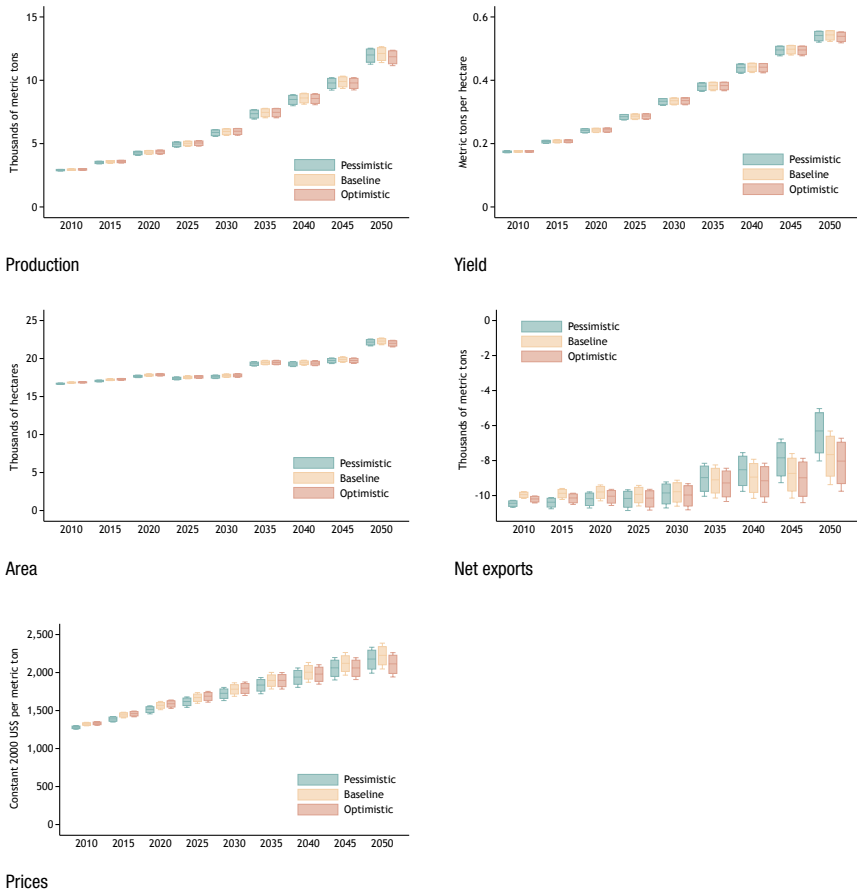


Source: Based on analysis conducted for Nelson et al. (2010).

Notes: The box and whiskers plot for each socioeconomic scenario shows the range of effects from the four future climate scenarios. GDP = gross domestic product; US\$ = US dollars.

Cotton production was at its lowest in 2010 but is expected to improve with government assistance. The world price of cotton, kept artificially low by subsidies paid to farmers in developed countries, erodes profits from growing cotton. The Swaziland government has committed to provide financial assistance for the purchase of cotton inputs and to support the price of cotton in order to encourage cotton production (Fibre2fashion 2008). Moreover,

**FIGURE 8.17** Impact of changes in GDP and population on cotton in Swaziland, 2010–2050



Source: Based on analysis conducted for Nelson et al. (2010).

Notes: The box and whiskers plot for each socioeconomic scenario shows the range of effects from the four future climate scenarios. GDP = gross domestic product; US\$ = US dollars.

the industry is evaluating the potential of genetically modified cotton to increase yield.

Swaziland is among the countries that currently benefit from the African Growth and Opportunity Act (AGOA), which enables countries to export goods and commodities to the United States duty free and which has promoted growth in the textile and apparel industry (AGOA 2000). Local demand for cotton is likely to increase, driven by the growing textile industry (Figure 8.17). The

cotton yield is projected to almost triple between 2010 and 2050, and with the area planted with cotton increasing by over 25 percent, total production might quadruple. Still, domestic demand is projected to grow, so imports of cotton are projected to decline only slightly.

### **Vulnerability to Climate Change**

The results from running the DSSAT crop model for the entire world were input into IMPACT, which computes global agricultural commodity prices and output by country and region. IMPACT was run with four climate model and scenario combinations. In particular, the CSIRO and the MIROC models were used, with the A1B and the B1 scenarios.<sup>2</sup> Those four combinations were run for each of the three per capita GDP scenarios (see Figure 8.11).

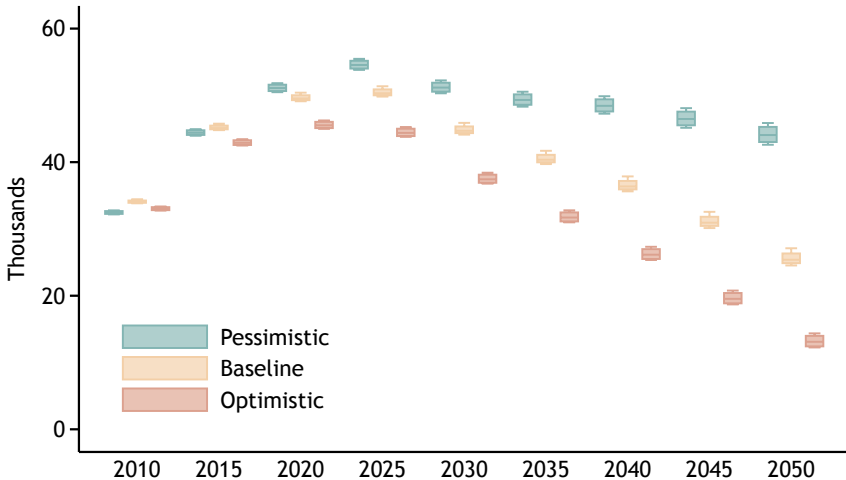
In addition to agricultural predictions, IMPACT also produces scenarios of the number of malnourished children under the age of five, as well as the available kilocalories per capita. Figure 8.18 shows the impact of future GDP and population scenarios on the number of malnourished children under age five; Figure 8.19 shows the share. In the optimistic scenario, the number of malnourished children is expected to increase from about 33,000 children currently to a peak of 44,000 in 2020, and then decrease to 13,000 in 2050. The assumption is that GDP will increase after 2020, making food (kilocalories) more readily available, as reflected in Figure 8.20. In the pessimistic scenario, however, the number of malnourished children will increase to a high of 55,000 and decrease only slightly by 2050, to 45,000. All the scenarios show malnutrition growing more widespread over the next 10 years in the absence of an effective policy intervention by the government. Such a policy should be developed with the aim of reducing poverty, and it could provide assistance to the vulnerable population in the form of food aid.

Figure 8.20 shows the kilocalories consumed per capita, and that number appears to be correlated with malnutrition in children and with GDP per capita. The decline in consumption under the pessimistic scenario reflects the steep increase in staple food prices that dominates the otherwise positive effect of the modest growth in GDP per capita in that scenario.

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<sup>2</sup> The B1 scenario is a greenhouse gas emissions scenario that assumes a population that peaks mid-century (like the A1B), but with rapid changes toward a service and information economy, and the introduction of clean and resource-efficient technologies.

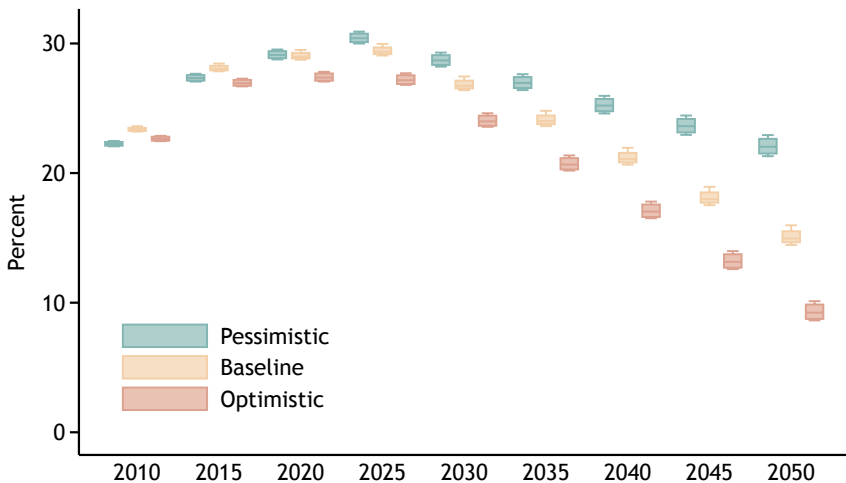
**FIGURE 8.18** Number of malnourished children under five years of age in Swaziland in multiple income and climate scenarios, 2010–2050



Source: Based on analysis conducted for Nelson et al. (2010).

Note: The box and whiskers plot for each socioeconomic scenario shows the range of effects from the four future climate scenarios.

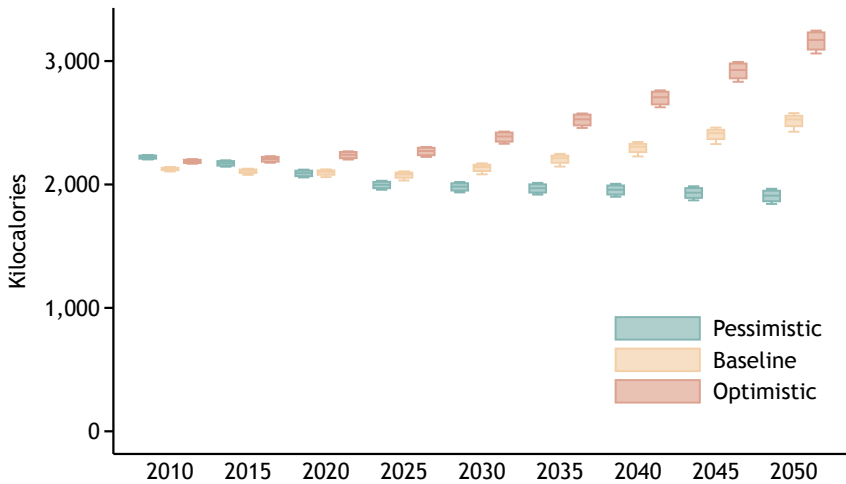
**FIGURE 8.19** Share of malnourished children under five years of age in Swaziland in multiple income and climate scenarios, 2010–2050



Source: Based on analysis conducted for Nelson et al. (2010).

Note: The box and whiskers plot for each socioeconomic scenario shows the range of effects from the four future climate scenarios.

**FIGURE 8.20** Kilocalories per capita in Swaziland in multiple income and climate scenarios, 2010–2050



Source: Based on analysis conducted for Nelson et al. (2010).

Note: The box and whiskers plot for each socioeconomic scenario shows the range of effects from the four future climate scenarios.

### Climate Change in Swaziland

Climate change and variability are evident in Swaziland in many forms, including hydrological disasters (droughts and storms), changes in rainfall regime, and extreme weather conditions (Manyatsi, Mhazo, and Masarirambi 2010).

Rural communities in Swaziland do not have adequate information on climate change. Limited information is available through the local radio in the form of daily weather forecasts that provide short-term information oriented to the major towns. Seasonal forecasting is provided by the National Meteorology Department of the Ministry of Tourism and Environmental Affairs.

These longer-term forecasts are often very technical and are not understood by the rural communities, including farmers. Climate change receives little coverage in the print media in Swaziland, except when it results in disasters or extreme conditions (Manyatsi 2008). A significant number of rural community members attribute climate change to nonscientifically proven causes, such as breakdowns of tradition, biblical manifestations, and supernatural powers (Manyatsi, Mhazo, and Masarirambi 2010). In formulating measures to mitigate the effects of climate change, the beliefs and concerns of the community need to be taken into consideration. The Ministry of Tourism and

Environmental Affairs has launched a competition to find a SiSwati name for climate change to help Swazis more easily understand the subject (*Swazi Observer* 2010b).

### **Coping with Climate Change**

Several livelihood strategies have been employed by communities to cope with hydrological disasters in Swaziland (Edje 2006; Manyatsi 2006; Manyatsi, Mhazo, and Masarirambi 2010; Manyatsi et al. 2010). Indigenous knowledge is used to predict or prevent hydrological disasters, and natural resources are used as a source of food and income. Indigenous methods of predicting hydrological events include observing the behavior of animals and the appearance of specific fruits. For example, the cry of *Cuculus solitarius*, a local bird, between August and November, is taken as a signal that the wet season will begin within two weeks (Manyatsi 2006). The restless and noisy behavior of pigs, peacocks, and ducks is taken as a sign of imminent heavy storms. The abundance of wild fruits—such as emantulwa (*Vangueria infausta*) and emaganu (*Sclerocarya birrea*)—between the months of December and February is a sign of imminent famine that season (Manyatsi 2006). Indigenous vegetables and fruits are used as alternative sources of food: ligusha (*Corchorus olitorius*), emantulwa (*Vangueria infausta*), and ematapha (*Scolopia mundi*) (Edje 2006). Wetland resources serve as sources of livelihood for the rural poor in times of drought, providing materials for handicrafts as well as sources of food and traditional medicine (Manyatsi et al. 2010).

Livelihood strategies and coping mechanisms practiced by communities in Swaziland are shown in Table 8.6. They include selling livestock in order to buy food and pay school fees, pooling resources through informal societies, and receiving food aid from the government, nongovernmental organizations (NGOs), and private companies.

The traditional social support system, made up of neighbors, relatives, and members of the household, plays an important role in responding to natural disasters. In the event of famine, neighbors assist one another in providing food, either in exchange for goods or favors (*kwenanisa*) or by selling them. In the event of a natural disaster, such as lightning striking a homestead, neighbors respond by calling for help, providing shelter, and providing food if the household's food reserve has been destroyed. Neighbors and relatives help out by plowing the fields of affected families that have lost cattle due to drought or lightning, either for free or in exchange for goods or favors (*kutsatsa*). Under the traditional system called *kusisa*, an affected

**TABLE 8.6** Livelihood strategies and coping mechanisms practiced by rural communities in Swaziland, 2010

Strategy	Ecological zone		
	Middleveld	Lowveld	Lubombo
Selling livestock in order to buy food and pay school fees	✓	✓	✓
Buying water from those with boreholes		✓	
Provision of food aid to community members by NGOs and private companies	✓	✓	✓
Getting food rations from other community members	✓	✓	✓
Getting water from schools that have boreholes and other reliable water sources		✓	
Harvesting water from roofs		✓	
Recycling water		✓	
Pooling resources through societies	✓	✓	✓
Giving elderly people social grants from the government	✓	✓	✓
Providing seeds and other farming inputs to needy members of the community by NGOs		✓	✓
Engaging in mixed cropping and crop diversification	✓		✓
Growing vegetables under irrigation	✓		

Source: Manyatsi, Mhazo, and Masarirambi (2010).

Note: NGOs = nongovernmental organizations.

household may be given cattle to look after in return for rights to the milk and use of the cattle for plowing.

A National Disaster Agency was set up under the deputy prime minister's office to assess the effects of natural disasters and to coordinate the response at a national level. The Coordinating Assembly of Non Governmental Organizations (CANGO), an umbrella body for all nongovernmental organizations in the country, includes about 60 organizations that are actively involved in social welfare and relief operations in the event of natural disasters, including the Swaziland Red Cross, World Vision, the Swaziland Farmers' Development Foundation, and the Women's Resource Center (CANGO 2010). The NGOs distribute food, blankets, and shelter to communities affected by natural disasters. They also play an important role in increasing food security by effecting improvements in agriculture productivity based on small-scale irrigation in the form of community gardens in which each household has a small plot.

### **Institutional Response to Climate Change**

Swaziland ratified the United Nations Framework Convention on Climate Change (UNFCCC) in 1996 and the Kyoto Protocol in 2006. The country produced its first national communication to the UNFCCC in 2000. That report provided a national inventory of anthropogenic emissions by sources, as well as of removal of greenhouse gases by sinks. On aggregate, Swaziland's overall status was as a net carbon dioxide sink. The predominant carbon uptake was by natural forests, commercial plantations, trees in towns, and wetlands plants (Swaziland, Ministry of Works 2000). A second national communication is currently in preparation.

The Ministry of Agriculture is responsible for undertaking research on crop varieties and livestock breeds appropriate to the Swaziland environment. The ministry also disseminates information on best agricultural practices through its Department of Extension Services. The National Meteorology Department (under the Ministry of Tourism and Environmental Affairs) is the country's focal point for climate change. The ministry recently established the Swaziland Climate Change Programme (SCCP) to address climate change issues in the country, implemented by the Meteorology Department and funded by the financial mechanism of the UNFCCC (the Global Environmental Facility) through the UN Development Programme (UNDP) (SCCP 2010). A permanent office has been established under the SCCP and is headed by a climatologist. A national climate change committee was established in September 2010 to coordinate the implementation of the SCCP. The committee, composed of 21 representatives of government ministries with diverse qualifications, is chaired by the climatologist from the Ministry of Tourism and Environmental Affairs (*Swazi Observer* 2010a).

Several public, private, and nongovernmental organizations play major roles in addressing climate change issues in the country in addition to the government ministries that are represented in the National Climate Change Committee. The public sector includes the University of Swaziland (UNISWA 2010), the Swaziland Water and Agricultural Development Enterprise (SWADE 2010), the Swaziland Water Services Corporation (SWSC 2010), and the Swaziland Electricity Company (SEC 2010).

Private-sector entities that have played a major role in climate change issues in the country include the financial sector, agricultural estates (such as the Royal Swaziland Sugar Corporation, Illovo Sugar, and United Plantations), and suppliers of agriculture inputs. The majority of the NGOs in Swaziland

are affiliated with the 63-member CANGO, which is engaged in coordination, capacity building, and policy advocacy, including on climate change issues. CANGO affiliates have also been engaged in developmental programs and programs to mitigate the effects of climate change; its membership includes many NGOs that work with communities at the grassroots level. CANGO was accordingly selected as the national focal point for the Food, Agriculture, and Natural Resources Policy Analysis Network (FANRPAN) (CANGO 2010).

Swaziland does not have a policy directly addressing the issues of climate change and climate change adaptation. However, several existing policies and laws are related to climate change, as shown in Table 8.7. They include the Forest Preservation Act of 1907, the National Trust Commission Act of 1972, the Water Act of 2003, and the Disaster Management Act of 2006.

Policies that address the issue of climate change and vulnerability to climate change include the Poverty Reduction Strategy and Action Plan (Swaziland, Ministry of Economic Planning and Development 2006), The Rural Settlement Policy of 2003 (Swaziland, Ministry of Agriculture and Cooperatives 2003), and the Forest Policy of 2002 (Swaziland, Ministry of Agriculture and Cooperatives 2002). The Poverty Reduction Strategy calls for fair distribution of the benefits of growth through fiscal policy and for empowerment of the poor to generate income, human capital development, and an improved quality of life. The Forest Policy aims to achieve efficient, profitable, and sustainable management and use of forest resources for the benefit of the entire society and to increase the role of forestry in environmental protection, conservation of plant and animal genetic resources, and rehabilitation of degraded land.

### **Projects and Programs Addressing Climate Change Issues**

- National projects that have implications for agriculture include the Maguga Dam project, the Komati Downstream Development Project (KDDP), the LUSIP, the Smallholder Agricultural Development Project, and the Earth Dam Rehabilitation Project. The Maguga Dam was constructed jointly by the Swaziland government and the South African government with the aim of harnessing water for irrigation downstream of the Komati River (KOBWA 2010). In Swaziland, the dam construction culminated in the implementation of the KDDP, which was designed to benefit a population of about 22,000 people and to develop 6,000 hectares of new irrigation schemes along the Komati basin.

**TABLE 8.7** Legislation in Swaziland relevant to climate change

Legislation	Relevance to climate change
Forests Preservation Act of 1907 (Swaziland, Ministry of Justice 1907)	Provides for the preservation of trees and forests growing on government and Swazi Nation land. Prohibits the cutting down, damage, removal, sale, or purchase of indigenous or government timber without the permission of the Minister of Agriculture.
Private Forests Act of 1951 (Swaziland, Ministry of Justice 1951)	Provides for the better regulation and protection of private forests in the country.
Grass Fire Act of 1955 (Swaziland, Ministry of Justice 1955)	Consolidates laws relating to grass burning and grass fires, which contribute to the accumulation of greenhouse gases. Regulates the interval and period when fire can be set on grass.
National Trust Commission Act of 1972 (Swaziland, Ministry of Justice 1972)	Provides for the establishment of national parks and monuments. The national parks are protected from anthropogenic activities, and the trees and other vegetation in them act as sinks for greenhouse gases produced elsewhere.
Waste Regulations of 2000 (Swaziland, Ministry of Justice 2000a)	Regulates the management of solid waste and liquid waste disposal on land. Prohibits persons from disposing of commercial or industrial waste or household waste produced in urban areas except at an approved waste disposal facility. Also prohibits the import of hazardous waste into the country.
Environmental Audit, Assessment and Review Regulations of 2000 (Swaziland, Ministry of Justice 2000b)	Requires any operator who undertakes development to submit an environmental assessment report and a comprehensive mitigation plan to the Swaziland Environmental Authority before permission can be given to undertake the development. The impact of the development on climate change is taken into consideration when reviewing the environmental assessment.
Environmental Management Act of 2002 (Swaziland, Ministry of Justice 2002)	Provides for and promotes the enhancement, protection, and conservation of the environment and the sustainable management of natural resources. Advocates for minimizing the generation of waste.
Water Act of 2003 (Swaziland, Ministry of Justice 2003)	Established a National Water Authority responsible for advising ministries on matters related to water use and distribution. Also established other institutions including the River Basin Authorities, the Water Apportionment Board, the Irrigation Districts, and the Water Users' Associations.
Disaster Management Act of 2006 (Swaziland, Ministry of Justice 2006)	Established a national disaster management policy in order to minimize potential losses from hazards and to provide timely and appropriate assistance to victims. Swaziland is prone to disasters associated with climate change, including droughts, famines, and occasional floods and storms.

Source: SEA and UNEP (2005).

- The LUSIP involved the construction of a dam to impound water diverted from the Usuthu River. The project is designed to develop 11,500 hectares for irrigation. Both the KDDP and the LUSIP are implemented by SWADE, a government-owned company (SWADE 2010) designed to assist the most disadvantaged agricultural producers on Swazi Nation land. Financed by the International Fund for Agricultural Development, its components include developing 185 hectares of new small-scale irrigation schemes and consolidating another 257 hectares of existing schemes to promote farmers' management of irrigation.
- The Earth Dam Rehabilitation and Construction program rehabilitated several medium-sized earth dams in the lowveld and lower middleveld, benefiting small-scale farmers.
- Government programs that address climate change issues include the CAADP, the SADP, and the Tractor Hire Pool program. The CAADP provides a strategic framework agreed to by the heads of states involved in the New Partnership for Africa's Development that is aimed at increasing national budget expenditure on agriculture to at least 10 percent and ensuring agriculture growth of at least 6 percent per year. Swaziland signed the CAADP framework in March 2010 (CAADP 2010).
- The SADP was established to improve smallholder production and marketing in order to achieve sustainable food security. Still in the formation stage, it will establish a Rural Youth Development Program, Junior Farmer Field and Life Schools, and Farmer Field Schools, among other projects. The program will also play a role in disseminating new crop varieties and livestock types approved by the Ministry of Agriculture.
- The government-subsidized tractor hire scheme, the Tractor Hire Pool, serves small-scale farmers. The government provides tractors or engages private tractor owners to plow for farmers, who pay subsidized fees for the service.

### **Conclusions and Policy Recommendations**

Climate change may have a significant effect on agriculture in Swaziland. Scenarios show temperatures increasing by as much as 2.5°C by 2050 and annual precipitation decreasing by more than 100 millimeters in the highveld and the

lowveld, the ecological zones where most of the maize is produced. Both the yield and the harvested area of maize would drop in these scenarios, resulting in an increased net import of maize with higher domestic prices of maize, making the staple food less affordable. Climate change scenarios coupled with GDP and population growth scenarios show the number of malnourished children increasing in the short run (up to the year 2025) and then decreasing.

Sugarcane, produced under irrigation, is less vulnerable to climate change as long as adequate water supplies are available. The harvested area planted in sugarcane is shown increasing as land is converted from other uses (such as livestock grazing and growing maize). Financial institutions more readily underwrite sugarcane production because of the perceived high financial returns from the sugar industry and the guaranteed demand from local sugar mills. Cotton production, too, is shown increasing but not enough to meet local demand, with most of the needed cotton being imported.

A National Committee has recently been established to spearhead the SCCP. The committee, made up of government officers, does not include representatives of public organizations, private organizations, or NGOs, and it has had little impact to date. In developing Swaziland's climate change policy, the National Committee needs to engage all relevant stakeholders to represent a broad range of interests.

There is a need to improve the understanding of local communities regarding climate change. Agricultural research needs to provide evidence to guide policy and to enable assessment of the potential impacts of climate change as well as climate change policies. Researchers need to take into account the ways farmers and communities currently adapt to weather variability and extreme events.

We make the following recommendations based on the study:

- The National Committee for the SCCP should facilitate the development of a climate change policy and climate change adaptation action plan, soliciting needed assistance (in the form of funding and expertise) from international organizations such as the UNDP, UNFCCC, and FANRPAN.
- Climate change should be addressed and streamlined in national agendas. Government agencies should facilitate dissemination of climate change information to stakeholders.
- The National Meteorology Department should produce simplified versions of seasonal weather forecast reports for farmers.

- Agricultural extension officers advising farmers on crop and livestock production should be sensitized to and trained in climate change issues, as well as in interpreting seasonal weather reports.
- The government should upscale the construction of small dams, especially in the lowveld area, which is more vulnerable to climate change. Communities could use the water captured to produce crops and vegetables to improve their livelihoods.
- If climate change reduces maize production and increases prices, people may have to replace this staple with other foods. Researchers and policymakers need to explore effective adaptations in light of this scenario.
- Farmers should grow drought-tolerant crops that can also withstand higher temperatures. National research institutions, together with seed suppliers, should ensure that drought-tolerant and heat-tolerant seeds are available and affordable, for example, through FANRPAN's Harmonized Seed Security Project.
- Vulnerable households (selected using reliable tools such as the Household Vulnerability Index) should be provided with food and agricultural inputs.

The challenge for policymakers is to respond fast enough to meet the urgency of the situation. Continuing dialogue between researchers and policymakers will provide mutual learning opportunities and ensure that the knowledge produced by researchers is both useful and used. FANRPAN has initiated national dialogues for engagement among stakeholders, and such dialogues have been useful in communicating climate change issues.

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