Chapter 1

OVERVIEW

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The part of Africa designated as West Africa is made up of 16 countries—Benin, Burkina Faso, Cape Verde, Côte d'Ivoire, Gambia, Ghana, Guinea, Guinea-Bissau, Liberia, Mali, Mauritania, Niger, Nigeria, Senegal, Sierra Leone, and Togo. Its land area is about 5 million square kilometers, and its population in 2010 was about 290 million. With the exception of Mauritania, these countries are members of the Economic Community of West African States (ECOWAS). The subregion comprises a diversified agricultural base spread over a wide range of agroecological zones with significant potential for improved agricultural productivity.

Agriculture is the major source of livelihood for the majority of West Africans. The agricultural sector employs 60 percent of the active labor force but contributes only 35 percent of gross domestic product (GDP). The disparity between contribution to GDP and share of population means that many West African farmers are very poor, producing close to subsistence levels and facing numerous constraints such as droughts, soil acidity, and nutrient-depleted and degraded soils that impinge on agricultural development. The most important foodcrops grown and consumed in West Africa are cereals—sorghum, millet, maize, and rice; roots and tubers—cassava, sweet potatoes, and yams; and legumes—cowpeas and groundnuts. Major cash crops are cocoa, coffee, and cotton.

Climate change, in terms of both climate means and variability, poses a great threat to farmers in the region. Possible impacts include reduced yields, lower farm incomes, and reduced welfare. There is increasing awareness of these threats among national governments and the regional economic community. Along with other African countries, the West African states have identified medium- and long-term adaptive measures in their national communications to the United Nations Framework Convention on Climate Change. Several of these countries have identified emergency priority measures for adaptation in their National Adaptation Programmes of Action (NAPAs), which center on agriculture, food security, and water resources management.

The purpose of this monograph is to help policymakers and researchers better understand and anticipate the likely impacts of climate change on agriculture and on vulnerable households. This is done by reviewing current data on agriculture and economic development, modeling plausible changes in climate between now and 2050, using crop models to assess the impact of climate changes on agricultural production, and globally modeling supply and demand for food in order to assess plausible food price trends. For each country, national authors worked with modeling results provided by the International Food Policy Research Institute (IFPRI) and then augmented them with other analysis as necessary. This is a unique initiative that capitalizes on the synergies among the respective countries covered in this study, the Conseil Ouest et Centre Africain pour la Recherche et le Developpement Agricoles (CORAF), and IFPRI to contribute to a climate-resilient agricultural system in West Africa.

This chapter provides an overview of the region, its current economic situation, and its vulnerability to climate change. It is designed to provide useful input into the efforts of ECOWAS in developing appropriate policies related to climate for the region. This chapter is followed by one that describes the common methodologies used by the authors of all country chapters and then by the individual country chapters. The monograph ends with a chapter that draws lessons for the region from the individual country studies.

The Intergovernmental Panel on Climate Change (IPCC), Climate Change and Agriculture, and Food Security

In the Fourth Assessment Report of the IPCC, Working Group 1 reports that "climate is often defined as 'average weather.' Climate is usually described in terms of the mean and variability of temperature, precipitation, and wind over a period of time, ranging from months to millions of years (the classical period is 30 years)" (Le Treut et al. 2007, 496).

The growth of greenhouse gas emissions is raising average temperatures. The consequences include changes in precipitation patterns, more and more extreme weather events, and shifting seasons. The accelerating pace of climate change, combined with global population and income growth, threatens food security everywhere.

Agriculture is vulnerable to climate change in a number of dimensions. Higher temperatures eventually reduce yields of desirable crops and tend to encourage weed and pest proliferation. Greater variations in precipitation patterns increase the likelihood of short-run crop failures and long-run production declines. Although there might be gains in some crops in certain regions of the world, the overall impacts of climate change on agriculture are expected to be negative, particularly in the Sahelian countries, threatening regional food security. The impacts are

- direct, on crops and livestock productivity domestically,
- indirect, on the availability or prices of food domestically and in international markets, and
- indirect, on income from agricultural production at both the farm and country levels.

Roudier et al. (2011) review 16 studies on the impact of climate change on West African agriculture. Müller (2011) uses the results of Roudier et al. together with the results of Neumann et al. (2010) to point out that in addition to climate change, there are existing inefficiencies in agriculture. The main points to take away from these studies, which have a lot of uncertainty built into them, are that it appears that climate change will unequivocally hurt agriculture and that right now there is room for improvements in yield with the proper investments.

More generally, Hertel and Rosch (2010) provide an insightful review of various approaches to analyzing the impacts of climate change on agriculture, as do Tubiello and Rosenzweig (2008).

Review of Current Regional Trends

This section provides an overview of the starting point for an assessment of the potential vulnerability of West African agriculture to climate change. It looks at recent population and income developments to provide a backdrop to potential futures. Two key indicators of well-being are reviewed—under-five mortality and life expectancy at birth. The current climate situation is discussed along with the role of regional programs in supporting food security.

Economic and Demographic Indicators

Population

The population of West Africa was estimated at 291.3 million in 2008 with Nigeria accounting for half of the total (Table 1.1). West Africa's population

TABLE 1.1 Population of West Africa, annualized growth rate, and percent urban, 1988 and 2009

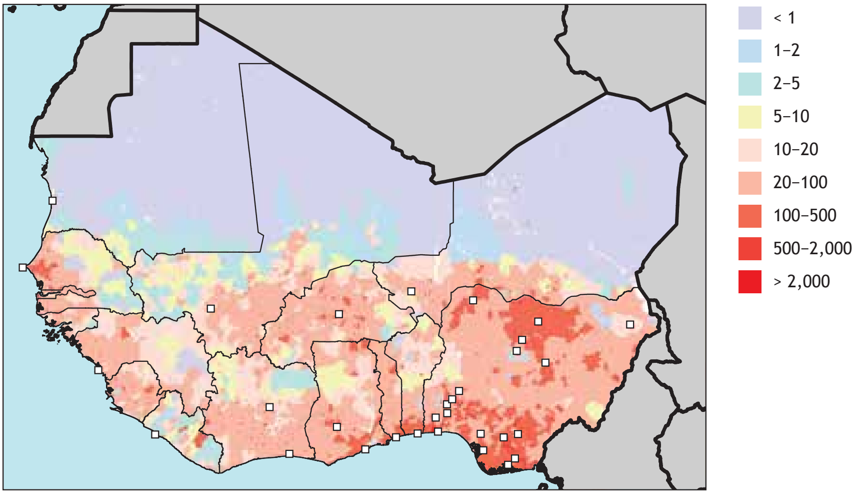
	Total population			Percent urban	
	Number (millions)				
Country	1988	2008	Annualized growth rate (%)	1988	2008
Benin	4.5	8.66	4.62	33	41
Burkina Faso	8.37	15.21	4.09	13	20
Cape Verde	0.34	0.50	2.35	39	60
Côte d'Ivoire	11.73	20.59	3.78	39	49
Gambia	0.83	1.66	5.00	36	56
Ghana	14.17	23.35	3.24	35	50
Guinea	5.74	9.83	3.56	27	34
Guinea-Bissau	0.98	1.58	3.06	26	30
Liberia	2.24	3.79	3.46	43	60
Mali	7.30	12.71	3.71	22	32
Mauritania	1.85	3.20	3.65	38	41
Niger	7.34	14.67	4.99	15	17
Nigeria	89.05	151.32	3.50	34	48
Senegal	7.11	12.21	3.59	38	42
Sierra Leone	3.95	5.56	2.04	32	38
Togo	3.70	6.46	3.73	29	42
Totals	169.20	291.30	3.61	32	43

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

increased by about 60 percent between 1988 and 2008, and the populations in many of the countries almost doubled. In general, there is growing urbanization resulting in higher population densities in capital cities and major towns (Figure 1.1). Rapid urbanization in the region is posing a great challenge to governments in providing basic amenities for the inhabitants. Increasing unemployment, particularly of youth, is a growing concern with serious sociopolitical implications.

Settlement areas in West Africa are linked to the current climate. Three-quarters of the population lives in the humid and subhumid zones, 20 percent in the semiarid zone (the Sahel), and 5 percent in the arid zone (ECOWAS–SWAC/OECD 2007). In all the countries, there is a general pattern of high population densities in and around urban areas. There is also a generally higher

FIGURE 1.1 Population distribution in West Africa, 2000 (persons per square kilometer)



Source: CIESIN et al. (2004).

population density along the coast. Nigeria also has a high population density in the states of Katsina, Kano, and Jigawa in the north (see Figure 1.1).

Income

Per capita GDP in West African states has been growing at diverse rates but invariably remains low across the region. In countries like Côte d'Ivoire, Guinea-Bissau, Liberia, Niger, and Togo, per capita GDP declined between 1988 and 2008 (Table 1.2). In most of these countries, the decline is attributed to civil wars and political unrest. Niger has suffered from adverse climatic conditions. In 2008, per capita GDP ranged from about 128 US dollars (US$128) in Guinea-Bissau to more than US$1,500 in Cape Verde, with all other countries having less than US$500 except Côte d'Ivoire (US$530) and Senegal (US$530).

Across the region, there has been a slow decline in the share of agriculture in overall GDP (see Table 1.2). This pattern occurs in all countries as economic development progresses. Specific causes include relatively slow increase in crop productivity and production and more rapid growth in the service sector, including tourism.

TABLE 1.2 Income of West Africans (GDP per capita and share of GDP from agriculture), 1988 and 2008

	GDP per capita (constant 2000 US$)		Share of GDP from agriculture (%)	
Country	1988	2008	1988	2008
Benin	313	359	34	n.a.
Burkina Faso	183	263	30	n.a.
Cape Verde	839	1,632	18	8
Côte d'Ivoire	695	530	32	24
Gambia	336	374	31	29
Ghana	212	327	50	32
Guinea	335	417	23	8
Guinea-Bissau	169	128	58	55
Liberia	539	148	38	n.a.
Mali	204	295	45	n.a.
Mauritania	429	n.a.	33	n.a.
Niger	206	180	35	n.a.
Nigeria	339	487	n.a.	31
Senegal	471	530	21	15
Sierra Leone	247	262	46	43
Togo	278	245	34	n.a.

Source: World Development Indicators (World Bank 2009a).
Notes: GDP = gross domestic product; n.a. = not available; US$ = US dollars.

Well-being indicators (regional)

Under-five mortality still remains relatively high in West Africa despite a decline in the figures between 1988 and 2008 (Table 1.3). Cape Verde has the lowest (32/1,000) under-five mortality in the region, while Sierra Leone has the highest (262/1,000). A majority of the countries have an under-five mortality ranging between 100 and 200. Life expectancy at birth is also generally improving across the region, with Cape Verde having the most favorable life expectancy at birth (71 years), while Guinea-Bissau, Nigeria, and Sierra Leone show an average life expectancy of only 47 years. The majority of the countries have a life expectancy of between 50 and 60 years. The general decrease in under-five mortality and increase in life expectancy are due to increasing campaigns for and implementation of vaccinations against major diseases and gradual improvement in health facilities.

TABLE 1.3 Under-five mortality and life expectancy at birth in West Africa, 1988 and 2008

	Under-five mortality (deaths per 1,000)		Life expectancy at birth (years)	
Country	1988	2008	1988	2008
Benin	184	123	54	61
Burkina Faso	206	191	50	52
Cape Verde	60	32	66	71
Côte d'Ivoire	151	127	57	57
Gambia	153	109	51	56
Ghana	120	115	58	56
Guinea	231	150	49	58
Guinea-Bissau	240	198	44	48
Liberia	205	133	49	58
Mali	250	196	48	54
Mauritania	130	119	58	64
Niger	304	176	47	57
Nigeria	230	189	47	47
Senegal	149	114	52	55
Sierra Leone	290	262	40	47
Togo	150	100	58	62

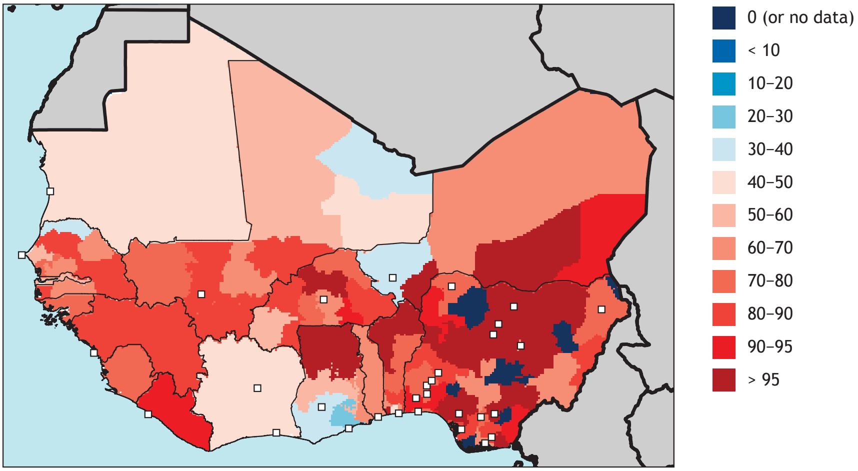
Source: World Development Indicators (World Bank 2009a).

Widespread poverty remains a challenge. Except for Côte d'Ivoire and Mauritania, where only 40–50 percent of the population lives on less than US$2 per day, an average of about 70–80 percent of the population lives on less than US$2 per day in all the other countries in the subregion (Figure 1.2). However, the coastal areas of Ghana and several states in Nigeria, including Lagos state and the federal capital state, have 20 percent to less than 10 percent of the population living on less than US$2 per day.

Climate, Land Use, and Agriculture

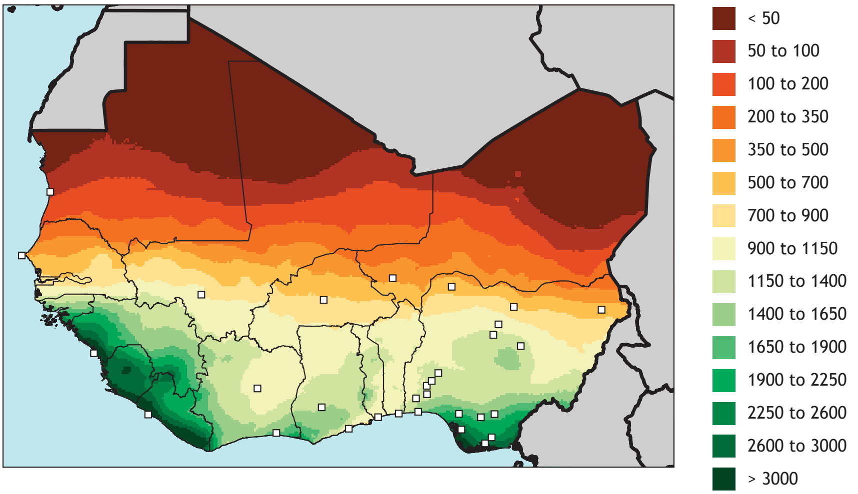
In West Africa today, rainfall generally decreases northward from the coast (Figure 1.3). The coasts of Guinea, Sierra Leone, Liberia, and Nigeria receive the highest amount of rainfall per year (ranging from 2,500 millimeters to more than 4,000 millimeters). In the Sahelian belt, extending from Senegal through Mali, Burkina Faso, Niger, and northern Nigeria, rainfall ranges from 800 to 1,100 millimeters, while Mauritania and most parts of Mali and Niger are largely

FIGURE 1.2 Poverty in West Africa, circa 2005 (percentage of population below US$2 per day)



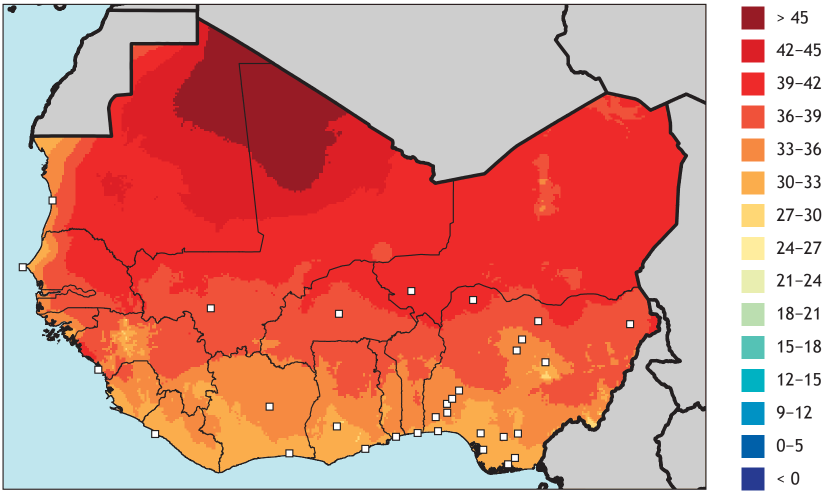
Source: Wood et al. (2010).
Note: Based on 2005 US$ (US dollars) and on purchasing power parity value.

FIGURE 1.3 Annual average precipitation in West Africa, 2000s (millimeters per year)



Source: WorldClim version 1.4 (Hijmans et al. 2005).

FIGURE 1.4 Annual maximum temperature in West Africa, 2000s (°C)



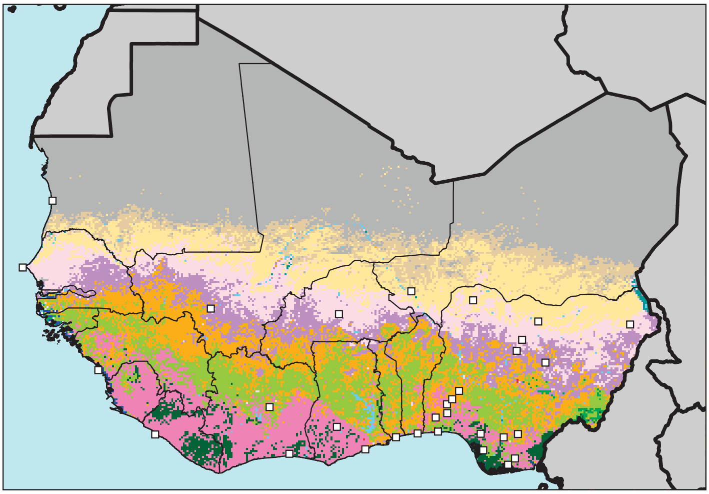
Source: WorldClim version 1.4 (Hijmans et al. 2005).

desert. As rainfall decreases, from south to north, temperature increases northward from the southern coast (Figure 1.4). Maximum temperatures range from 30°–33°C along the coast to 36°–39°C in the Sahel and 42°–45°C on the fringe of the desert.

As precipitation declines, the agroecology of West Africa shifts from humid forest along the coast to the Guinea savanna and the Sudan savanna northward (Figure 1.5). As a result of shifting cultivation and indiscriminate logging, only patches of the Guinea forest that once stretched from Guinea through Nigeria now remain. The belt of savanna (mostly the Sudan savanna) that stretches from northern Senegal across Mali, Burkina Faso, Niger, and northern Nigeria is referred to as the Sahel. The Sudan savanna of the Sahel merges into the Sahara Desert in the north. In general, plantation tree crops as well as root crops dominate the humid coastal areas, while cereals become predominant northward. The Sahelian region is dominated by a crop/livestock production system.

The existing farming systems, including the crops and livestock, have largely adapted to the respective agroecosystems in the region. Major imbalances in these agroecosystems could be caused by changes in climate, thereby affecting livelihoods in the region. Dwindling forests and consequently increasing

FIGURE 1.5 Regional land use distribution in West Africa, 2000



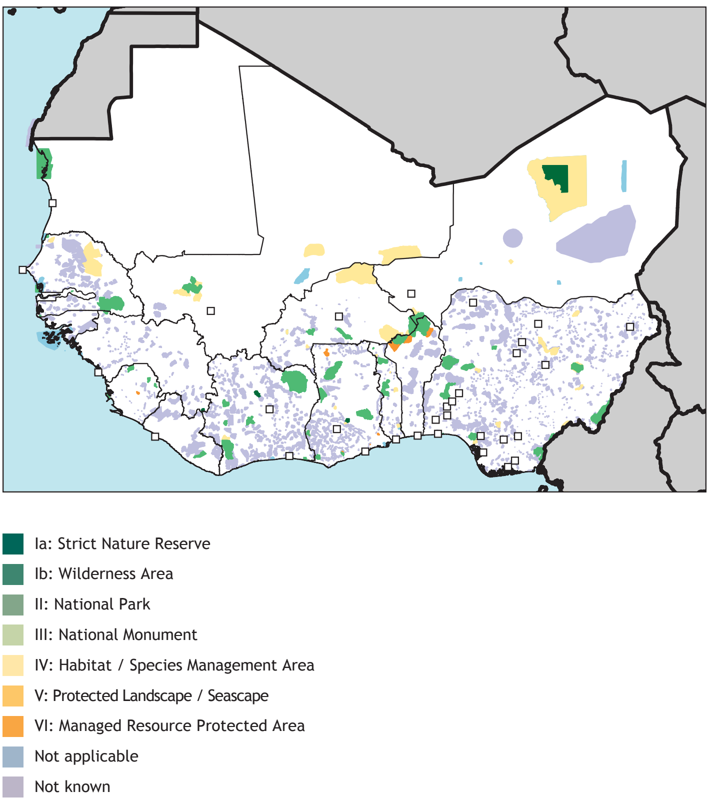
- Tree cover, broadleaved, evergreen
- Tree cover, broadleaved, deciduous, closed
- Tree cover, broadleaved, deciduous, open
- Tree cover, broadleaved, needle-leaved, evergreen
- Tree cover, broadleaved, needle-leaved, deciduous
- Tree cover, broadleaved, mixed leaf type
- Tree cover, broadleaved, regularly 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
- Herbacious cover, closed-open
- Sparse herbacious or sparse shrub cover
- Regularly flooded shrub or herbacious 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 (Global Land Cover 2000) (Bartholome and Belward 2005).

savannahs could provide unfavorable conditions for farming systems suited to forest conditions, while such a situation could be good for systems that require relatively drier conditions. This could require adjustments to living conditions, including land tenure. There is, however, growing awareness of the adverse effects of deforestation in the region. Many governments are increasingly supporting initiatives aimed at conserving and protecting key natural resources, including forests (Figure 1.6).

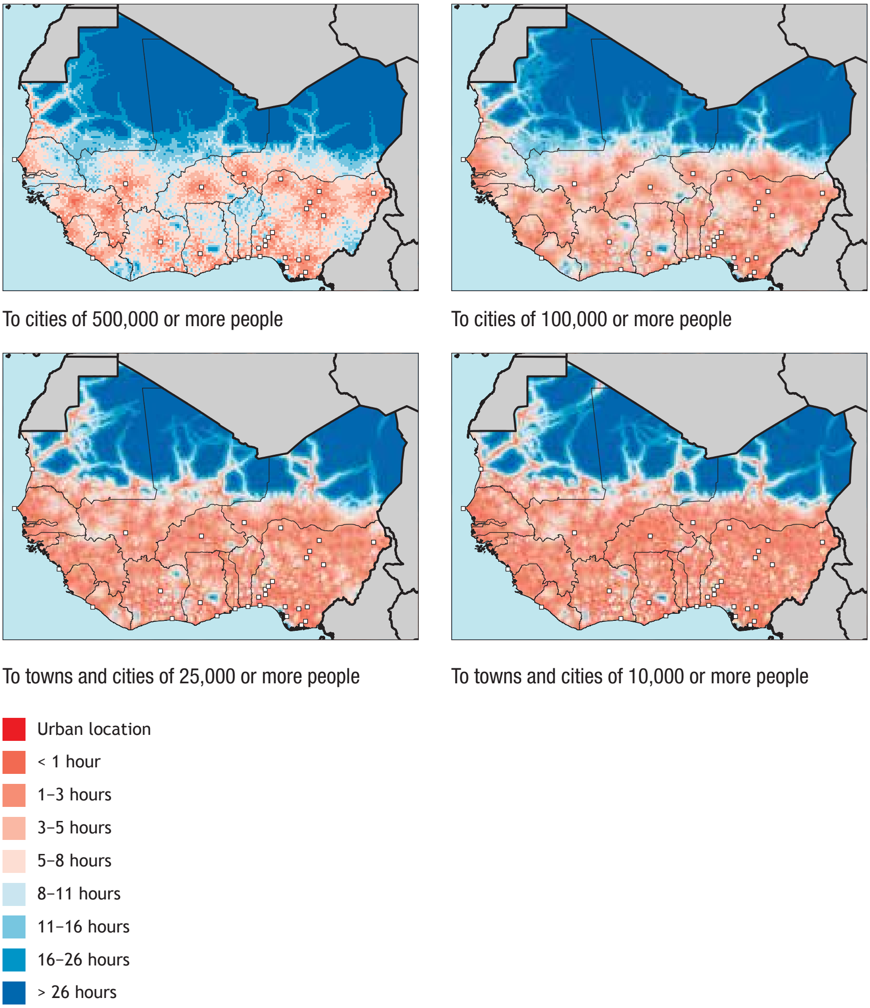
In general, major cities are linked within each country (Figure 1.7), a major highway runs along the coast from Côte d'Ivoire to Nigeria, and a major linkage in the north connects Senegal, Guinea, Mali, and Burkina Faso. Coastal countries like Côte d'Ivoire, Ghana, Togo, Benin, and Nigeria are also linked with

FIGURE 1.6 Protected areas in West Africa, 2009



Sources: Protected areas are from the World Database on Protected Areas (UNEP and IUCN 2009). Water bodies are from the World Wildlife Fund's Global Lakes and Wetlands Database (Lehner and Döll 2004).

FIGURE 1.7 Travel time in West Africa, 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.

their adjacent landlocked countries. There is a need to upgrade these international highways to facilitate regional trade.

Tables 1.4–1.7 provide information on the major crops grown in West Africa. The major cereals are maize, millet, rice, and sorghum (see Table 1.4). Millet occupies the largest area among the cereal crops, followed by sorghum. Both crops are mainly produced in the Sahelian countries (Burkina Faso, Mali,

TABLE 1.4 Average harvest area of leading agricultural commodities in West Africa, grains, 2005–07 (thousands of hectares)

Country	Maize	Millet	Rice (paddy)	Sorghum	Total
Benin	679	42	30	149	900
Burkina Faso	509	1,328	51	1,613	3,501
Cape Verde	31	0	0	0	31
Côte d'Ivoire	292	61	375	67	795
Gambia	37	127	23	24	211
Ghana	764	190	122	333	1,409
Guinea	403	377	781	48	1,608
Guinea-Bissau	16	29	73	20	137
Liberia	0	0	160	0	160
Mali	382	1,566	429	998	3,380
Mauritania	25	10	18	182	235
Niger	9	6,410	20	2,859	9,303
Nigeria	3,898	4,977	2,519	7,579	19,014
Senegal	167	793	93	175	1,229
Sierra Leone	60	25	1,000	22	1,107
Togo	475	69	32	221	797
Total	7,747	16,002	5,726	14,289	43,815

Source: FAOSTAT (FAO 2010).

TABLE 1.5 Average harvest area of leading agricultural commodities in West Africa, pulses and nuts, 2005–07 (thousands of hectares)

Country	Beans, dry	Cashew nuts	Cowpeas	Groundnuts	Soybeans	Total
Benin	145	212	0	116	19	492
Burkina Faso	0	9	702	385	5	1,101
Cape Verde	0	0	0	0	0	0
Côte d'Ivoire	32	657	0	68	1	758
Gambia	0	0	0	120	0	120
Ghana	0	61	0	470	0	531
Guinea	0	3	0	210	0	212
Guinea-Bissau	0	212	2	24	0	239
Liberia	0	0	0	9	8	17
Mali	0	0	245	332	3	581
Mauritania	10	0	23	1	0	34
Niger	18	0	4,743	460	0	5,221
Nigeria	0	327	4,395	2,251	626	7,599
Senegal	0	16	187	624	0	827
Sierra Leone	0	0	0	150	0	150
Togo	188	0	0	57	0	246
Total	394	1,496	10,298	5,277	661	18,127

Source: FAOSTAT (FAO 2010).

TABLE 1.6 Average harvest area of leading agricultural commodities in West Africa, root crops, bananas, and plantains, 2005–07 (thousands of hectares)

Country	Bananas	Cassava	Plantains	Potatoes	Sweet potatoes	Yams	Total
Benin	3	175	0	0	26	185	389
Burkina Faso	0	2	0	1	7	3	12
Cape Verde	0	0	0	0	1	0	2
Côte d'Ivoire	8	339	382	0	25	723	1,476
Gambia	0	3	0	0	0	0	3
Ghana	7	797	301	0	65	299	1,469
Guinea	41	139	84	2	63	2	330
Guinea-Bissau	1	4	14	0	0	0	19
Liberia	11	85	19	0	2	2	120
Mali	4	6	0	5	13	3	31
Mauritania	0	0	0	0	2	0	3
Niger	0	5	0	2	3	0	10
Nigeria	0	3,821	464	266	1,086	3,068	8,705
Senegal	1	67	0	1	1	0	70
Sierra Leone	0	73	7	0	12	0	91
Togo	2	130	0	0	0	60	193
Total	77	5,645	1,271	277	1,307	4,346	12,922

Source: FAOSTAT (FAO 2010).

TABLE 1.7 Average harvest area of leading agricultural commodities in West Africa, other crops, 2005–07 (thousands of hectares)

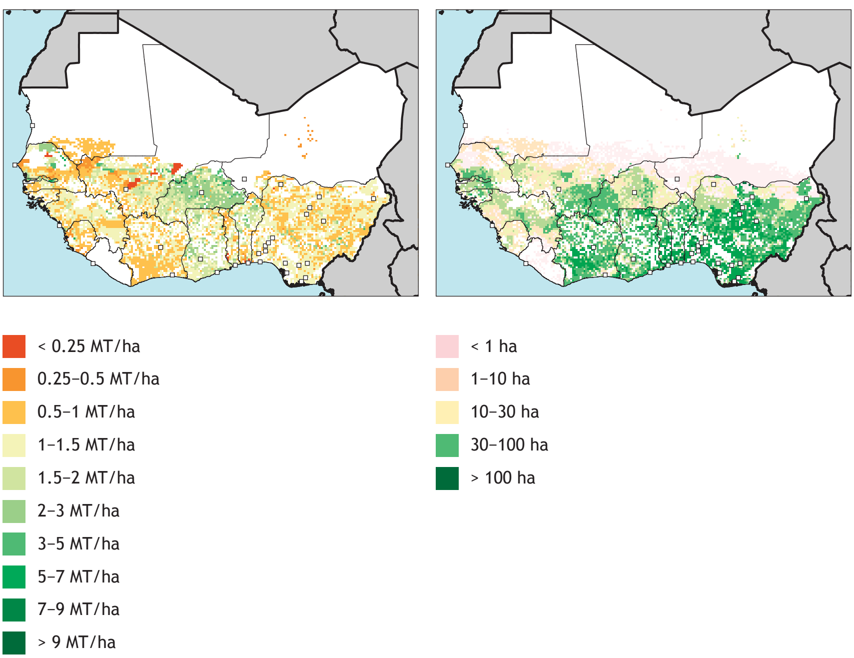
Country	Cocoa beans	Coffee grain	Seed cotton	Sesame seeds	Sugar cane	Total
Benin	0	0	225	11	1	238
Burkina Faso	0	0	483	51	5	538
Cape Verde	0	0	0	0	1	1
Côte d'Ivoire	2,151	585	247	6	25	3,015
Gambia	0	0	1	7	0	8
Ghana	1,678	10	25	0	6	1,718
Guinea	17	48	36	2	5	108
Guinea-Bissau	0	0	4	0	0	4
Liberia	17	17	0	0	26	60
Mali	0	0	320	14	5	339
Mauritania	0	0	5	73	4	82
Niger	1,110	4	513	201	57	1,884
Nigeria	0	0	44	27	7	78
Senegal	38	11	0	4	1	54
Sierra Leone	104	34	67	5	0	210
Togo	5,115	709	1,970	401	143	8,339
Total	394	1,496	10,298	5,277	661	18,127

Source: FAOSTAT (FAO 2010).

and Niger) and northern Nigeria. Cowpeas and groundnuts are the major legumes cultivated in the region (see Table 1.5). Niger and Nigeria dominate cowpea production, while Nigeria leads the region in groundnut production, followed by Senegal, Ghana, and Niger. Cassava is the major root crop grown and consumed in West Africa (see Table 1.6). The major cash crops in the region are cocoa, coffee, and cotton (see Table 1.7). Cocoa and coffee production are confined to the humid forest areas along the coast, while cotton is produced mainly in savannah regions, particularly in Nigeria, Burkina Faso, Mali, Côte d'Ivoire, and Benin.

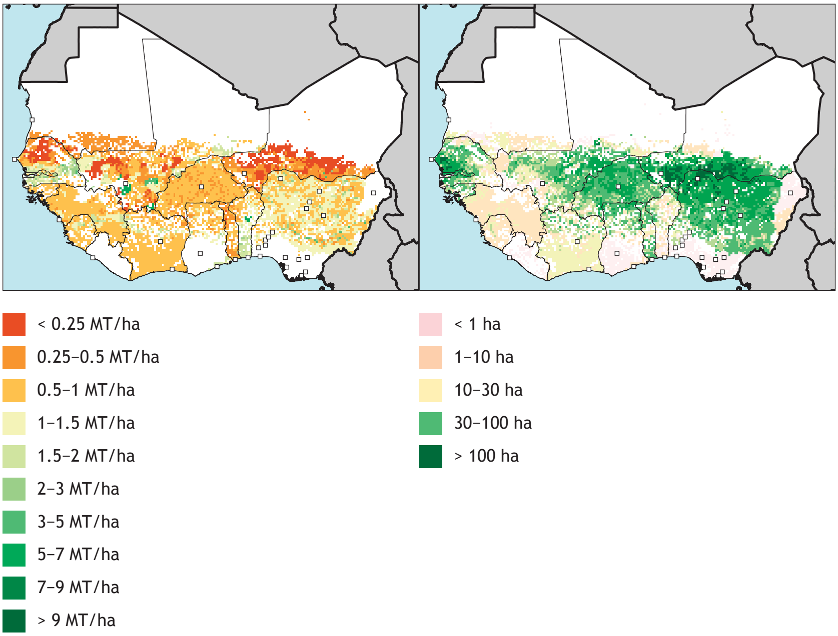
Figures 1.8–1.11 show the distribution and yield of major cereal crops grown in West Africa. Rainfed maize is produced across the region, with major producing countries being Côte d'Ivoire, Ghana, Togo, Benin, and Nigeria (see Figure 1.8). Millet (see Figure 1.9) and sorghum (see Figure 1.10) are produced mainly in the Sahel and the northernmost parts of the coastal countries.

FIGURE 1.8 Yield (metric tons per hectare) and harvest area density (hectares) for rainfed maize in West Africa, 2000



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

FIGURE 1.9 Yield (metric tons per hectare) and harvest area density (hectares) for millet in West Africa, 2000



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

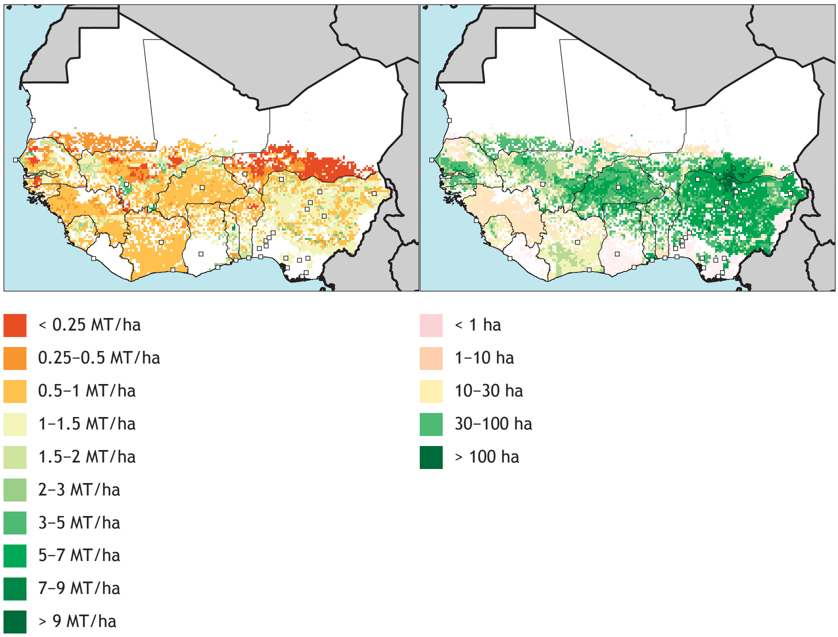
Similar to maize production, rice production is concentrated in the coastal countries (see Figure 1.11). Rainfed cereal yields are still very low in West Africa compared to the world average and even other regions in Africa. Rice and maize yield an average of 1 metric ton per hectare, while sorghum and millet yield about 0.5 ton per hectare.[1] Against the background of limited inputs, the predominantly resource-poor farmers are faced with such biophysical constraints as pests and diseases, droughts, soil acidity, and nutrient-depleted and degraded soils. The threats of climate change could prove most challenging to an already overstretched production system.

Regional Program on Food Security

West Africa is unique in Africa in terms of the degree of regional economic integration efforts. The premier institution in this regard is ECOWAS, a regional

1 All tons are metric tons.

FIGURE 1.10 Yield (metric tons per hectare) and harvest area density (hectares) for sorghum in West Africa, 2000



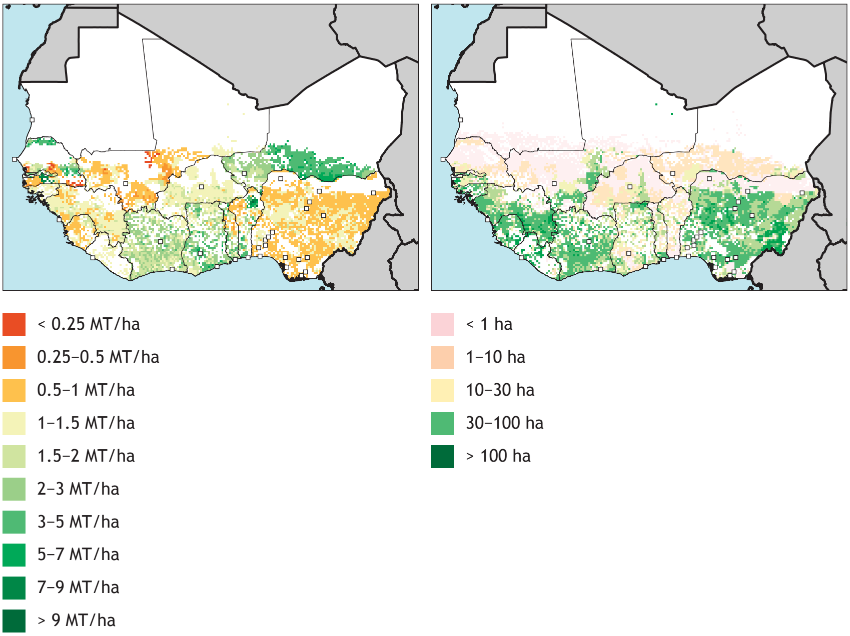
Sources: SPAM (Spatial Production Allocation Model) (You and Wood 2006; You, Wood, and Wood-Sichra 2006, 2009).
Notes: ha = hectare; MT/ha = metric tons per hectare.

group of 15 countries founded in 1975. Its mission is to promote economic integration in "all fields of economic activity, particularly industry, transport, telecommunications, energy, agriculture, natural resources, commerce, monetary and financial questions, social and cultural matters" (ECOWAS 2012).

The framework for the ECOWAS Agricultural Policy (ECOWAP) was adopted by member heads of state and government in January 2005. The three major themes of the ECOWAP policy framework are

1. increasing the productivity and competitiveness of West African agriculture,
2. implementing a trade regime in West Africa, and
3. adapting the trade regime vis-à-vis countries outside the region (ECOWAS 2008).

FIGURE 1.11 Yield (metric tons per hectare) and harvest area density (hectares) for rice in West Africa, 2000



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

In July 2005, ECOWAS drew up a regional action plan for the implementation of ECOWAP and the Comprehensive Africa Agriculture Development Programme of the New Partnership for Africa's Development in the period 2006–10 based on six priorities for joint implementation of National Agricultural Investment Programmes (NAIPs) and long-term Regional Agricultural Investment Programmes (RAIPs):

1. improved water management by promoting irrigation and integrated water resource management;
2. improved management of other natural resources through organized transhumance and rangeland development, sustainable forest resources management, and sustainable fishery resources management;

3. sustainable agricultural development at the farm level through integrated soil fertility management, better support services for producers, and dissemination of improved technologies;
4. development of agricultural supply chains and promotion of markets by developing the different supply chains (foodcrops, periurban agriculture, export crops, short-cycle livestock rearing, agroforestry food products, and artisanal fishing and fish farming), developing processing operations, strengthening support services for operators, and promoting national, international, and regional trade;
5. prevention and management of food crises and other natural disasters by promoting early warning systems, developing crisis management systems, assisting the recovery of crisis-hit areas, and formulating mechanisms for disaster-related insurance and compensation; and
6. institution building through gender-sensitive approaches, support for capacity building in the formulation of agricultural and rural policies and strategies, long-term funding for agriculture, communication, and capacity building in steering and coordination and in monitoring and evaluation.

ECOWAS recognizes the intricate relationship between agriculture and climate and therefore the potential impact of climate change on agricultural production. This is reflected in the list of priorities for NAIPs and long-term RAIPs. What is needed now is the explicit mainstreaming of climate change in these programs. It is expected that a well-integrated regional market will not only provide a much-needed pull for agricultural produce, thereby encouraging further increase in production, but will also provide an opportunity to respond to regional imbalances in production as a result of climate. Therefore, since the international conference on the mitigation of vulnerability to climate change in natural, economic, and social systems in West Africa, held in Burkina Faso in January 2007, ECOWAS has elaborated a subregional program of action to mitigate vulnerability to climate change in West Africa. The program of action emphasizes efforts to stem soil degradation on the one hand and, on the other, to foster technical and institutional synergies for climate adaptation in the region.

TABLE 1.8 Summary statistics for assumptions on West Africa's population and per capita GDP used in the IMPACT model, 2010 and 2050

		2050		
Category/country	2010	Optimistic	Baseline	Pessimistic
Population (millions)				
Benin	9,212	19,402	21,982	24,744
Burkina Faso	16,287	36,189	40,830	45,757
Cape Verde	513	595	703	822
Côte d'Ivoire	21,571	37,845	43,373	49,350
Gambia	1,751	3,292	3,763	4,270
Ghana	24,333	39,660	45,213	51,163
Guinea	10,324	21,131	23,975	27,025
Guinea-Bissau	1,647	3,147	3,555	3,990
Liberia	4,102	7,730	8,841	10,040
Mali	13,323	24,941	28,260	31,792
Mauritania	3,366	5,304	6,061	6,873
Niger	15,891	52,568	58,216	64,156
Nigeria	158,259	254,129	289,083	326,395
Senegal	12,861	22,814	26,102	29,620
Sierra Leone	5,836	10,904	12,446	14,100
Togo	6,780	11,481	13,196	15,054
Income per capita (2000 US$)				
Benin	373	2,539	1,397	149
Burkina Faso	340	2,579	1,428	791
Côte d'Ivoire	710	6,265	3,401	1,536
Gambia	412	3,162	1,724	750
Ghana	543	4,975	2,724	988
Guinea	162	2,140	835	683
Guinea-Bissau	697	5,234	2,876	1,456
Liberia	85	1,594	394	347
Mali	417	3,818	2,108	1,122
Niger	221	1,671	637	559
Nigeria	344	2,491	1,364	684
Senegal	678	5,602	3,055	1,362
Sierra Leone	337	2,566	1,410	378
Togo	309	2,653	1,438	660

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

Notes: 2010 income per capita is for the baseline scenario. GDP = gross domestic product; IMPACT = International Model for Policy Analysis of Agricultural Commodities and Trade (International Food Policy Research Institute); US$ = US dollars.

Scenarios for the Future

Population and Income Scenarios

All scenarios for the future, described further in Chapter 2, include a significant increase in the population of West African countries except for Cape Verde by 2050 (Table 1.8). In the pessimistic scenario, populations of all countries in the region with the exception of Cape Verde will more than double. A similar outcome occurs in the baseline scenario for all countries except Cape Verde and Nigeria. In the optimistic scenario, the population doubles only in Benin, Burkina Faso, and Niger. Income per capita does not improve significantly in the pessimistic scenario and could even decline in the case of Benin (see Table 1.8). However, in the optimistic scenario income per capita in 2050 could range from US$1,594 for Liberia to US$6,265 for Côte d'Ivoire.

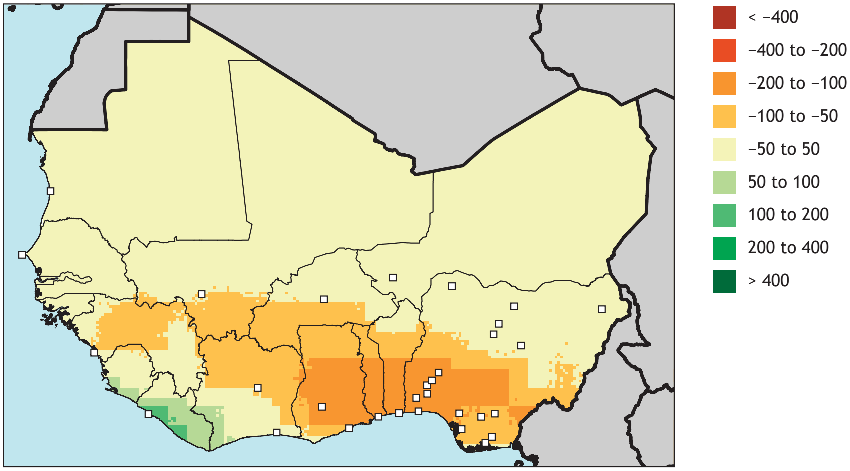
Climate Change Scenarios and Their Effects on Agriculture

The rainfall scenarios used in this monograph are generally dissimilar (Figures 1.12 and 1.13).[2] There is similarity in the predictions for reduction in rainfall in the southern parts of Ghana, Togo, Benin, and Nigeria, but the CSIRO A1B scenario has a greater reduction in precipitation than the MIROC A1B scenario.[3] The CSIRO A1B scenario predicts no change to as much as 100 millimeters per year decline in the Sahelian region and an increase in precipitation along the coast of Sierra Leone and most parts of Liberia, while the MIROC A1B scenario predicts an increase in precipitation in the Sahelian region (50–100 to 100–200 millimeters per year) and severe drought in Liberia (a decline of 200–400 millimeters per year). As indicated earlier, a substantial change in climate could require adjustments for which resource-poor farmers lack the essential means. Heavy and persistent rainfall in hitherto dry areas of the Sahel could cause an increase in diseases and pests that livestock in those areas are not adapted to. On the other hand, a marked decrease in rainfall in hitherto wet regions like Liberia could cause significant changes in the growing conditions that may require changes in the farming system with

2 See Chapter 2 for details on how these scenarios were produced.

3 CSIRO and MIROC are acronyms for two of the general circulation models (GCMs) discussed in this book. CSIRO is a climate model developed at the Australia Commonwealth Scientific and Industrial Research Organisation. MIROC is the Model for Interdisciplinary Research on Climate, developed at the University of Tokyo Center for Climate System Research. The A1B scenario is a 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.

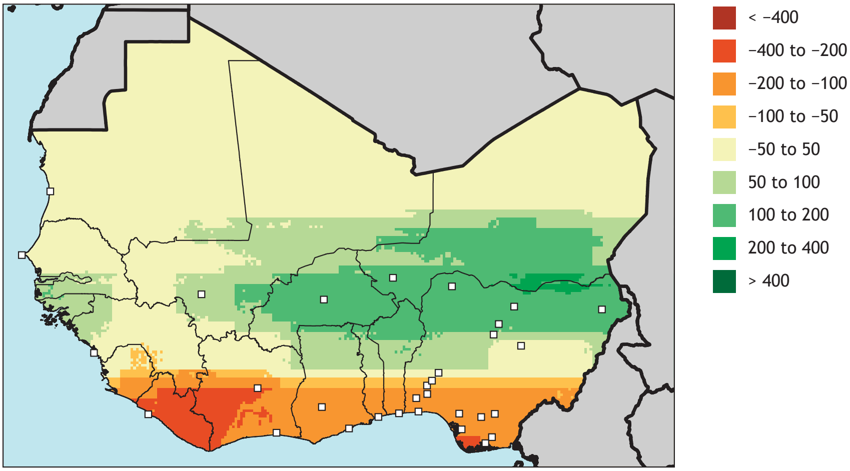
FIGURE 1.12 Change in average annual precipitation in West Africa, 2000–2050, CSIRO A1B (millimeters)



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; CSIRO = climate model developed at the Australia Commonwealth Scientific and Industrial Research Organization.

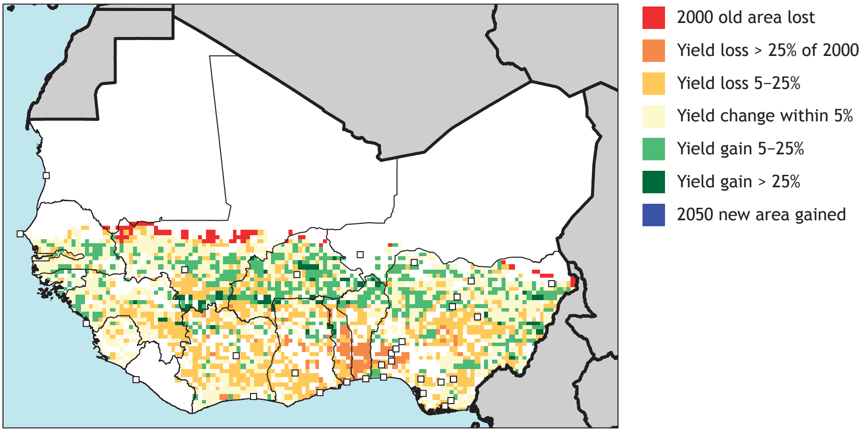
FIGURE 1.13 Change in average annual precipitation in West Africa, 2000–2050, MIROC A1B (millimeters)



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; MIROC = Model for Interdisciplinary Research on Climate, developed at the University of Tokyo Center for Climate System Research.

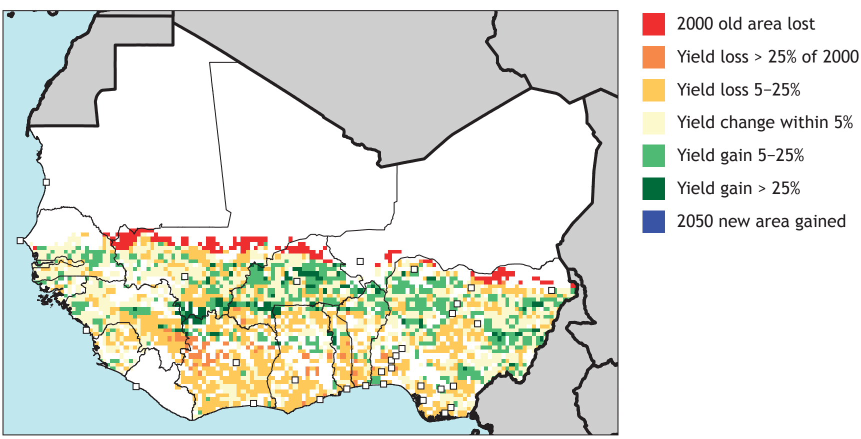
FIGURE 1.14 Changes in yields (percent), 2000–2050, from the DSSAT crop model, maize (rainfed), CSIRO A1B



Source: Authors' estimates.

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 source; CSIRO = climate model developed at the Australia Commonwealth Scientific and Industrial Research Organisation; DSSAT = Decision Support Software for Agrotechnology Transfer.

FIGURE 1.15 Changes in yields (percent), 2000–2050, from the DSSAT crop model, maize (rainfed), MIROC A1B



Source: Authors' estimates.

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; MIROC = Model for Interdisciplinary Research on Climate, developed at the University of Tokyo Center for Climate System Research.

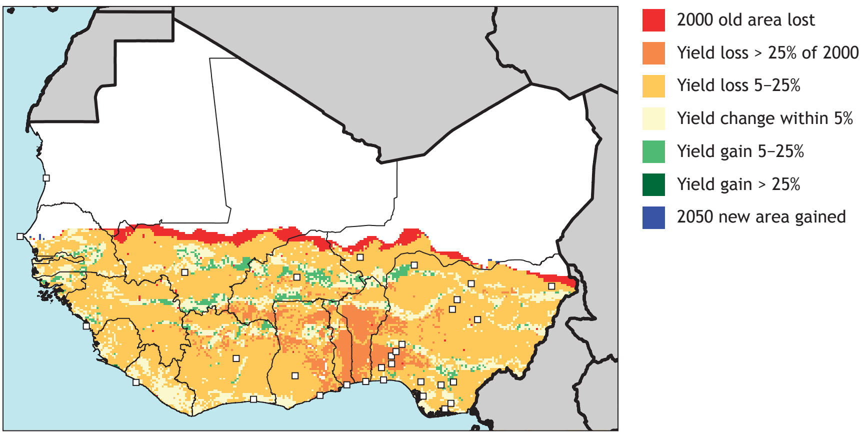
regard to crops and livestock composition and management. The real issue is the inability of resource-poor farmers to react appropriately and fast enough.

Crop models using the CSIRO and the MIROC general circulation models' climate outputs predict a general decrease in maize yields of 5–25 percent of baseline in most parts of the countries along the southern coast of West Africa and a yield gain of 5–25 percent in the Sahel (Figures 1.14 and 1.15). Both models also have a loss in baseline area in the northernmost parts of Mali, Burkina Faso, and Nigeria.

Based on both the CSIRO and the MIROC climate outcomes in the A1B SRES (Special Report on Emissions Scenarios) scenario, sorghum yields will decline by 5–25 percent across West Africa, with greater reductions in parts of Togo, Benin, and adjacent areas of Ghana and Nigeria (Figures 1.16 and 1.17). Both climate scenarios also have a loss in baseline area in the Sudan savanna from Senegal to Nigeria. However, the MIROC scenario has a greater reduction than the CSIRO scenario.

Rainfed rice yields are predicted to decrease by 5–25 percent in most parts of Côte d'Ivoire, Ghana, and Togo based on both the CSIRO and the MIROC models (Figures 1.18 and 1.19) and in Nigeria as well based on the

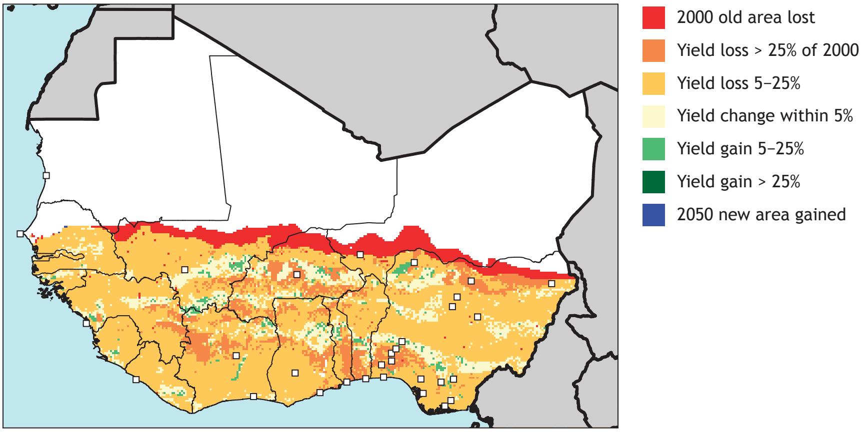
FIGURE 1.16 Changes in yields (percent), 2000–2050, from the DSSAT crop model, sorghum (rainfed), CSIRO A1B



Source: Authors' estimates.

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; CSIRO = climate model developed at the Australia Commonwealth Scientific and Industrial Research Organisation; DSSAT = Decision Support Software for Agrotechnology Transfer.

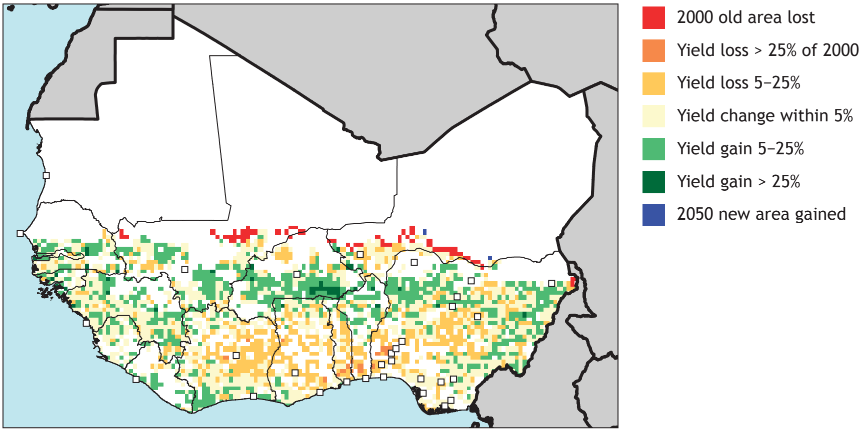
FIGURE 1.17 Changes in yields (percent), 2000–2050, from the DSSAT crop model, sorghum (rainfed), MIROC A1B



Source: Authors' estimates.

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; DSSAT = Decision Support Software for Agrotechnology Transfer; MIROC = the Model for Interdisciplinary Research on Climate, developed at the University of Tokyo Center for Climate System Research.

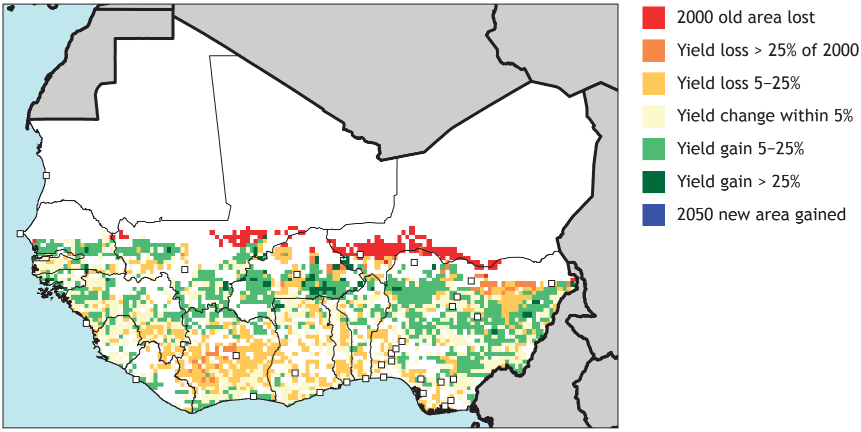
FIGURE 1.18 Changes in yields (percent), 2000–2050, from the DSSAT crop model, rice (rainfed), CSIRO A1B



Source: Authors' estimates.

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; CSIRO = climate model developed at the Australia Commonwealth Scientific and Industrial Research Organisation; DSSAT = Decision Support Software for Agrotechnology Transfer.

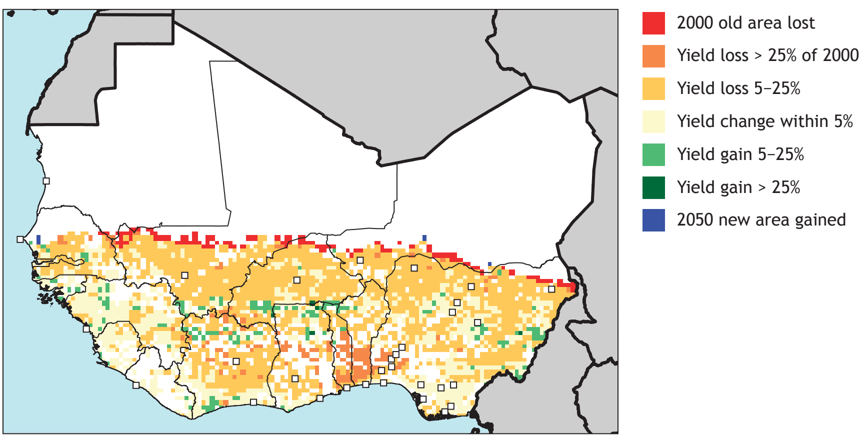
FIGURE 1.19 Changes in yields (percent), 2000–2050, from the DSSAT crop model, rice (rainfed), MIROC A1B



Source: Authors' estimates.

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; DSSAT = Decision Support Software for Agrotechnology Transfer; MIROC = Model for Interdisciplinary Research on Climate, developed at the University of Tokyo Center for Climate System Research.

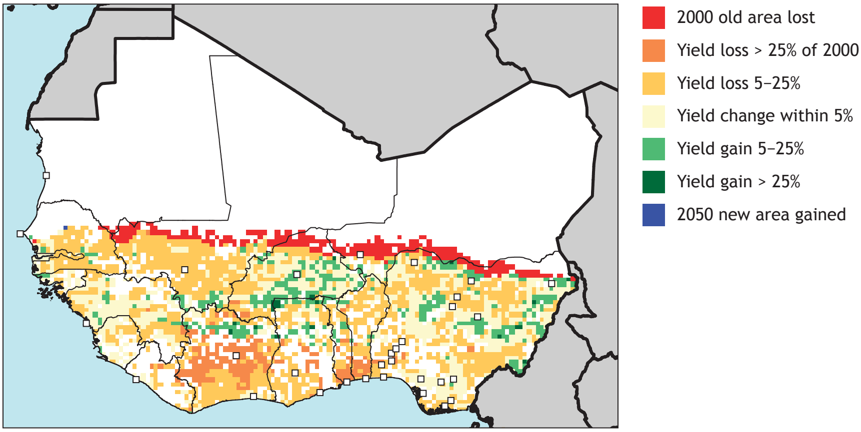
FIGURE 1.20 Changes in yields, 2000–2050, from the DSSAT crop model, groundnuts (rainfed), CSIRO A1B



Source: Authors' estimates.

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; CSIRO = climate model developed at the Australia Commonwealth Scientific and Industrial Research Organisation; DSSAT = Decision Support Software for Agrotechnology Transfer.

FIGURE 1.21 Changes in yields, 2000–2050, from the DSSAT crop model, groundnuts (rainfed), MIROC A1B



Source: Authors' estimates.

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; DSSAT = Decision Support Software for Agrotechnology Transfer; MIROC = Model for Interdisciplinary Research on Climate, developed at the University of Tokyo Center for Climate System Research.

CSIRO model (Figure 1.20). Both models also have an increase in rice yield in the Sahelian belt, while baseline area will be lost in Mali and Niger.

Both the CSIRO A1B and the MIROC A1B results show a decline in rainfed groundnut yield across West Africa, but the impact will be relatively less in the Mano River Union countries of Guinea, Liberia, and Sierra Leone (see Figures 1.20 and 1.21). However, both models show certain areas of the northern parts of Côte d'Ivoire, Ghana, Burkina Faso, and Nigeria with an increase in yield of 5–25 percent. In this regard, the MIROC model is more positive than the CSIRO, though more area is lost in the MIROC model, so in that sense it is less positive.

In general, both climate models (CSIRO and MIROC) indicate declining rains along the coasts of Nigeria, Togo, Benin, Ghana, and Côte d'Ivoire, while there is either increased rainfall (MIROC) or slight dryness or wetness in the Sahel (CSIRO). This outcome seems to be related to the relatively higher prevalence of yield gain for both rice and maize in the Sahel compared to the more pronounced yield loss in the coastal areas. The increase in wetness in the Sahel may suggest an unfavorable condition for drought-tolerant and -adapted sorghum, with yield loss under increasingly wet conditions. This scenario suggests that farmers could face various predicaments and the need to adapt to conditions they are not used to.

TABLE 1.9 Global commodity prices, 2010 and 2050 (2000 US$ per metric ton)

		2050					
		Pessimistic		Baseline		Optimistic	
Crop	Model price, 2010	Min	Max	Min	Max	Min	Max
Maize	111	209	265	216	272	200	253
Millet	341	305	327	291	307	267	283
Rice	239	433	441	378	388	323	328
Sorghum	145	184	193	184	193	175	184
Wheat	146	218	252	222	254	206	236

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

Notes: The minimum (min) and maximum (max) price increases arise from the differences in the climate model effects on yields. US$ = US dollars.

TABLE 1.10 Maize changes in West Africa under the baseline scenario, 2010 and 2050

	2010			2050					
				Yield (MT/ha)		Area (thousands of ha)		Production (MT)	
Country	Yield (MT/ha)	Area (thousands of ha)	Production (MT)	Min	Max	Min	Max	Min	Max
Benin	1.08	748	810	1.87	2.08	886	929	1,660	1,911
Burkina Faso	1.41	458	646	2.20	2.61	408	424	900	1,105
Côte d'Ivoire	1.11	745	824	1.98	2.09	787	825	1,601	1,661
Gambia	1.93	16	31	2.55	2.73	17	18	43	48
Ghana	1.52	825	1,255	2.44	2.59	945	990	2,311	2,538
Guinea	1.15	138	159	2.14	2.29	161	168	344	386
Guinea-Bissau	1.90	16	31	2.03	2.15	18	19	37	41
Mali	1.39	381	531	2.31	2.61	304	313	703	803
Niger	0.78	4	3	1.57	1.69	1	2	2	3
Nigeria	1.29	4,696	6,070	1.74	1.90	4,405	4,829	7,664	9,181
Senegal	1.98	132	263	2.76	2.90	144	151	398	439
Sierra Leone	1.92	10	20	2.98	3.10	10	11	30	33
Togo	1.11	477	531	1.78	2.01	318	334	567	661

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

Notes: The minimum (min) and maximum (max) price increases arise from the differences in the climate model effects on yields. ha = hectares; MT = metric tons.

Regional Agricultural Outcomes

Scenarios reflecting the prices of major foodcrops are presented in Table 1.9. World market prices for maize, rice, sorghum, and wheat are predicted to increase in all scenarios, while the price of millet will be less in 2050 than in 2010. In 2050, prices for millet, rice, sorghum, and wheat will be higher in the pessimistic scenario than in the optimistic scenario as the higher populations of the pessimistic scenario combine with lower income to increase demand for these crops.

The production of maize (Table 1.10), millet (Table 1.11), and sorghum (Table 1.12) is predicted to increase in West Africa by 2050. The area under cultivation of both millet and sorghum will increase, while the area under cultivation of maize will decrease. The productivity of all three crops is assumed to increase due to increased use of inputs under improved management practices and assuming the availability of improved varieties. It is, however,

TABLE 1.11 Millet changes in West Africa under the baseline scenario, 2010 and 2050

	2010			2050					
				Yield (MT/ha)		Area (thousands of ha)		Production (MT)	
Country	Yield (MT/ha)	Area (thousands of ha)	Production (MT)	Min	Max	Min	Max	Min	Max
Benin	0.75	48	36	2.21	2.35	80	85	180	198
Burkina Faso	0.83	1,369	1,142	2.34	2.62	1,669	1,760	3,992	4,539
Côte d'Ivoire	0.55	95	52	1.65	1.75	143	152	237	267
Gambia	1.29	102	132	2.85	2.92	156	166	447	485
Ghana	0.78	211	166	1.68	1.74	333	354	562	616
Guinea	0.77	19	14	2.45	2.54	16	17	40	44
Guinea-Bissau	1.49	31	46	2.77	2.93	48	52	134	151
Mali	0.67	1,726	1,149	2.17	2.54	2,067	2,204	4,641	5,408
Niger	0.46	5,964	2,737	1.23	1.51	6,190	7,915	9,188	10,570
Nigeria	1.31	5,555	7,299	3.12	3.23	5,580	5,895	17,727	19,010
Senegal	0.51	831	425	1.39	1.42	1,267	1,358	1,758	1,922
Sierra Leone	1.14	8	9	2.52	2.61	8	8	20	22
Togo	0.81	62	51	1.82	1.93	78	83	145	160

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

Notes: The minimum (min) and maximum (max) price increases arise from the differences in the climate model effects on yields. ha = hectares; MT = metric tons.

TABLE 1.12 Sorghum changes in West Africa under the baseline scenario, 2010 and 2050

Country	2010			2050					
				Yield (MT/ha)		Area (thousands of ha)		Production (MT)	
	Yield (MT/ha)	Area (thousands of ha)	Production (MT)	Min	Max	Min	Max	Min	Max
Benin	0.90	211	190	1.96	2.06	375	385	739	787
Burkina Faso	1.02	1,594	1,632	1.86	2.08	1,952	1,981	3,638	4,109
Côte d'Ivoire	0.62	107	67	1.25	1.29	167	171	210	219
Gambia	1.64	25	41	3.51	3.59	41	42	144	151
Ghana	0.95	369	352	2.04	2.09	631	647	1,290	1,342
Guinea	0.63	10	6	1.40	1.43	8	8	11	12
Guinea-Bissau	0.99	27	27	1.97	2.05	45	46	89	93
Mali	0.86	983	846	2.70	3.03	1,142	1,176	3,142	3,517
Niger	0.46	2,329	1,075	1.19	1.42	2,724	3,360	3,847	4,241
Nigeria	1.15	8,412	9,675	2.04	2.13	9,947	10,145	20,336	21,617
Senegal	0.79	188	149	1.74	1.77	315	323	550	571
Sierra Leone	1.91	10	20	2.83	2.88	14	14	39	41
Togo	1.16	236	274	2.32	2.45	321	329	747	803

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

Notes: The minimum (min) and maximum (max) price increases arise from the differences in the climate model effects on yields. ha = hectares; MT = metric tons.

important to note that despite the projected increases in yields of these crops, the maximum yields are far lower than the potential for these crops and even lower than the yields currently obtained in developed countries. For example, although developed countries now typically get over 5 tons per hectare, the highest projected yield for maize is only 3.10 tons per hectare (in Sierra Leone), whereas the highest yields for millet (Nigeria) and for sorghum (Gambia) are below 4 tons per hectare. Against the possible limitations of climate, the low use of fertilizers could partly account for the low productivity of these crops. Compared with a current total world consumption of fertilizers of approximately 150 million tons and an application rate of 100 kilograms per hectare of arable land, Africa south of the Sahara (SSA) is stranded at 6 kilograms per hectare. The projected annual growth rate in SSA before 2030 is a dismal 1.9 percent per year (FAO 2003). This situation calls for a holistic strategy including the development of appropriate production technologies as

TABLE 1.13 Number of malnourished children in West Africa, 2010 and 2050 (thousands)

		2050					
		Pessimistic		Baseline		Optimistic	
Country	2010	Min	Max	Min	Max	Min	Max
Benin	423	741	794	520	554	375	404
Burkina Faso	1,047	1,439	1,462	1,159	1,180	866	887
Côte d'Ivoire	740	851	904	500	541	222	254
Gambia	48	59	60	28	29	6	7
Ghana	836	977	1,057	620	683	365	417
Guinea	420	526	555	312	334	127	145
Guinea-Bissau	102	92	96	65	68	0	2
Liberia	312	365	384	295	310	61	72
Mali	7,817	8,410	8,720	6,325	6,596	4,338	4,587
Nigeria	884	915	946	605	631	313	337
Niger	1,398	2,821	2,846	2,485	2,506	1,757	1,776
Senegal	449	388	400	169	178	13	21
Sierra Leone	242	450	462	227	236	108	116
Togo	254	274	296	168	185	80	94

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

Notes: Min (minimum) represents the smallest projected number from the simulations based on the CSIRO A1B, CSIRO B1, MIROC A1B, and MIROC B1 climate model/scenario combinations. Max (maximum) represents the largest of the four simulated values. 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; B1 = greenhouse gas emissions scenario that assumes a population that peaks midcentury (like the A1B), but with rapid changes toward a service and information economy and the introduction of clean and resource-efficient technologies; CSIRO = climate model developed at the Australia Commonwealth Scientific and Industrial Research Organisation; MIROC = Model for Interdisciplinary Research on Climate, developed at the University of Tokyo Center for Climate System Research.

well as enabling farmers to access vital inputs required for improved productivity and production under climate change conditions.

Vulnerability Outcomes

In the optimistic scenario, the number of malnourished children decreases for all the countries in West Africa except Niger (Table 1.13). In the pessimistic scenario, the number increases in all countries except Guinea-Bissau and Senegal. The results are mixed in the baseline scenario. It is important to keep in mind that although in some cases the absolute number of malnourished children increases, in most cases this still represents a drop in the proportion of children who are malnourished because the populations will increase significantly between now and 2050.

Adaptation and Means of Implementation

The challenges to the agricultural sector and its stakeholders from a changing climate are growing and pose a serious threat to the welfare of people in the region, particularly farmers. Although higher temperatures are likely, the magnitude of the increase is uncertain, and the effects will differ across the region depending on which climate scenario eventually occurs. Precipitation outcomes are even more uncertain. The general consequences of drought and excess availability of water on the physiology and productivity of crops are largely known. However, the effects of changes in climate on the limits of tolerance of existing varieties as well as the possible emergence of diseases and pests will be a real challenge.

Consequently, possible avenues for adaptation must include dealing with drought, floods, high temperatures, waterlogging, new and increasing incidence of plant pests and diseases, a shorter growing season, and associated human health concerns, such as malaria and sleeping sickness in the Sahel due to wetter conditions favorable to mosquitoes and tsetse flies. Selection and breeding of appropriate varieties will be crucial in any adaptation venture. Developing appropriate management practices of such varieties is imperative.

Against the background of the debate on the relative emphasis on adaptation and mitigation, it is worth noting that in many instances the best bets for improved agricultural production and sustainable management of natural resources also have considerable mitigation potential (see Nin-Pratt et al. 2011 for an analysis of the best opportunities for productivity research). The existing traditional farming practices in West Africa, notably shifting cultivation, burning as a means of clearing, inefficient use of paddies, indiscriminate plowing of lands, and so on, offer significant avenues for improvement that will also reduce the production of greenhouse gasses and conserve the natural resource base needed by farmers in the region. The World Bank (2009b) reported that although Africa accounts for only 4 percent of global carbon dioxide emissions, more than 60 percent of its emissions are due to deforestation and land degradation. Therefore, crop intensification, minimum tillage, and agroforestry coupled with designation and maintenance of protected forests will go a long way toward carbon sequestration as well as conserving and improving the natural resource base.

Finance, Technology, and Capacity Building

The majority of farmers in West Africa are resource poor. In addition to biophysical constraints to their farming pursuits, lack of access to funds as well as markets severely limits their ability to break out of the vicious circle of poverty. In view of their scale of production, targeted subsidies coupled with microcredit with practical and reasonable collateral requirements will go a long way toward enabling small-scale farmers to acquire vital inputs required for boosting production. In addition, access to payments for carbon credits will encourage farmers to join hands in the global effort to meet the challenges of climate change.

It is critical that appropriate technologies be available for farmers to effectively undertake adaptation and mitigation measures. There is also a need for appropriate awareness raising to inform mostly illiterate farmers about how to efficiently use technologies as well as to ensure that they are aware of their rights and are able to negotiate for benefits. In this regard, CORAF, with a mandate to coordinate agricultural research in West and Central Africa, has developed a strategic framework to guide climate change research in its mandate region, including West Africa. The strategy identifies priority research areas for climate change adaptation and mitigation and provides for capacity building, knowledge management, and partnerships in the context of an IAR4D (Integrated Agricultural Research for Development) approach. This monograph supports that mandate of CORAF in researching the impact of climate change on agriculture, not only providing important data and analysis but also helping to identify future research issues. It also assists planners and policymakers in the region to identify areas that need to be strengthened and potential positive changes that they might capitalize.

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