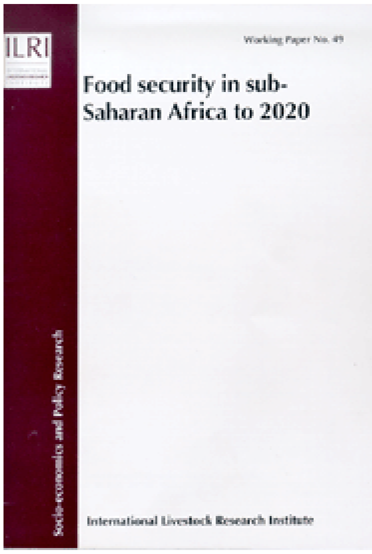
Food security in sub-Saharan Africa to 2020

Socio-economics and Policy Research Working Paper 49



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Executive summary

This paper presents an outlook on food security in sub-Saharan Africa (SSA) to 2020. It discusses the challenges and opportunities for meeting the food security of the poor vulnerable groups and examines policy strategies for achieving future food security in the region.

Over the past two decades (1975–95), per capita consumption of cereals stagnated in most sub-regions of SSA. Per capita consumption of cereals increased only slightly from 109 kg in 1975 to 114 kg in 1995 for the entire SSA, with central and western SSA recording the lowest per capita consumption. With respect to livestock products, although the average per capita consumption of meat, milk and eggs in the world increased significantly, those in SSA either stagnated or declined or increased only slightly. Per capita consumption of meat, milk and eggs in SSA in 1995 were only 9.5, 23.9 and 1.4 kg, respectively, which were about 27, 31 and 20% of the respective world averages.

The 2020 projections show that per capita consumption of food crops and livestock products will increase only modestly, although total consumption will double between 1997 and 2020 as a result of rapid population growth. In terms of food utilisation, total daily calories supply will increase by 10% over the 1997 level to reach 2442 calories per capita, while the number of malnourished children under the age of five will increase by 20% (or 6.7 million children), with most of the increases taking place in northern SSA.

Looking at alternative scenarios that mimic the dismal past performance of SSA, where gross domestic product (GDP) growth is low and agricultural productivity and investments are declining, the total daily calorie supply will fall below the 1997 level to 2162 per capita, and the number of malnourished children will increase rapidly to more desirable growth path similar to that projected for other developing countries, where total daily calorie supply is 3232 per capita and the number of malnourished children is 22 million, SSA needs policies and strategies that can help address the challenges and exploit the opportunities to achieve future food security. These include improving health and education, especially for women; increasing investments in agricultural research that leads to improved crop and livestock technologies to increase production, provide greater employment opportunities and higher wages, lower food prices, and reduce the vulnerability of the poor to shocks via asset accumulation; improving markets, infrastructure, and institutions so that poor farmers can obtain remunerative prices for their outputs. Good governance and integrating the civil society in decision making and sharing of national benefits to avoid civil conflicts are also crucial.

However, given that no one-size-fits-all strategy will achieve food security everywhere in the region, specific policy and investment strategies should build upon and improve the various development pathways (livelihood strategies) that exist in different situations and agro-ecological zones (the humid, sub-humid, semi-arid, arid and highlands).

1 Introduction

Sub-Saharan Africa (SSA)[1] is the most important development challenge of the 21st century. World development indicators show that in 1998 the total production (gross domestic product (GDP)) of the region amounted to only US$ 201 billion, less than one percent of the world's total production (World Bank 2002). In 1970, the economy of the region was larger than that of Brazil. Today, it is only about one-fourth the size of Brazil's. Furthermore, poverty is higher in most African countries than elsewhere in the developing world, with about 40% of the population of SSA living on less than one dollar a day. Those most vulnerable to poverty live in rural areas and large households that are often headed by women; education is low and they are also most likely to live in countries with real growth rates of less than 5% (World Bank 2000). SSA accounts for nearly one-fourth of the world's poor, where 19 of the 25 poorest countries in the world are found (Dixon et al. 2001). It is estimated that out of the world's 800 million people that are food insecure, about 180 million (or 23%) of them live in SSA (Pinstrup- Andersen et al. 2001). In this paper, we provide an outlook on food security in SSA to 2020. We also discuss the challenges and opportunities for meeting the food security of the poor vulnerable groups. Then, we examine the impacts of domestic policies, external influences, research and other factors on future food security in the region.

1. Excludes South Africa unless otherwise stated.

Food security is defined as physical and economic access by all people at all times to sufficient food to meet their dietary requirements for a productive and healthy life. Three conditions must thus be satisfied to ensure food security: food must be available through domestic production and imports; food must be accessible or people must have adequate resources to acquire the appropriate foods; and food must be utilised in conjunction with adequate water, sanitation and health to meet nutritional needs. Often however, food security is discussed with reference to grains only. This can be misleading especially for societies (e.g. pastoral societies) that are primarily dependent on sources of food other than grains. In fact, livestock have a very important role in achieving food security in SSA (Ehui et al. 1998; Ehui 1999). Livestock production contributes about 35% of agricultural gross domestic product (GDP) in SSA. In addition to direct food production, livestock provide multipurpose uses such as skins, fibre, fertiliser, traction, fuel and capital accumulation. Animal products are also good sources of absorbable forms of iron, zinc, vitamin B_{12}, retinol and many other minerals highly essential for child growth. Sales of livestock products such as meat, milk and egg generate income and, thus, increase the purchasing power of livestock owners. Livestock and livestock products are also the most important `cash crop' in many small smallholder mixed farming systems of the region. Therefore, this paper focuses on issues pertaining to both crops and livestock in achieving food security.

In the next section, we examine the recent trends (1975–95) in food consumption, production and trade in SSA. In Section 3, we provide projections to 2020. Section 4 discusses the challenges and opportunities for meeting the food security of the poor vulnerable groups. Impacts of domestic policies, external influences, research, and other factors on future food security are discussed in Section 5. In addition, policy and investment strategies for achieving future food security in the specific sub-regions are discussed. Conclusions are drawn in Section 6.

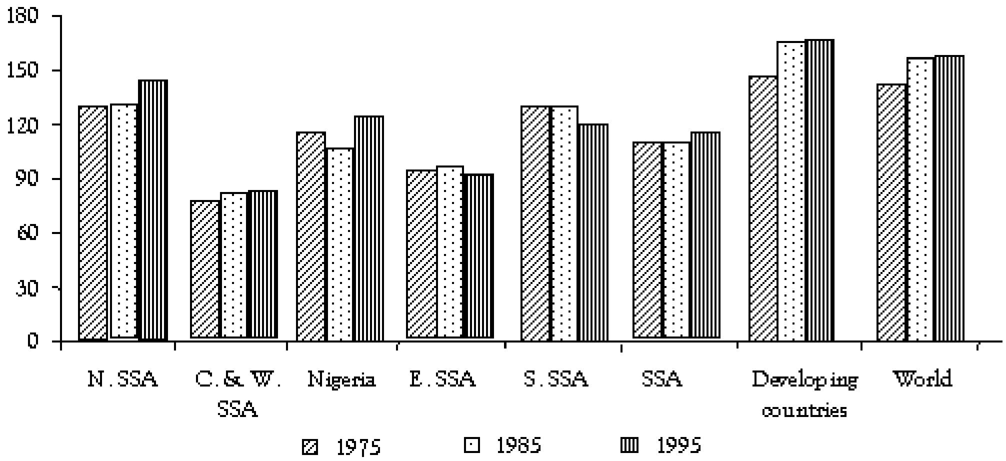
2 Recent trends in food consumption, production and trade

[2.1 Consumption]

[2.2 Production and trade]

2.1 Consumption

Per capita consumption of cereals stagnated in most of the sub-regions of SSA.[2] In the period between 1975 and 1995, consumption of milk in the entire region stood at about 70% of the world's average (Figure 1). The per capita consumption of cereals increased by only 5%, rising from 109 kg in 1975 to 114 kg in 1995. Central and western SSA recorded the lowest per capita consumption of cereals: only 82 kg in 1995. Per capita consumption of roots and tubers also stagnated or declined in much of SSA between 1975 and 1995 (Figure 2). Although, here, central and western SSA recorded the highest per capita consumption (76 kg in 1995), reflecting the importance of roots and tubers in the diets of people in those areas. Per capita consumption of roots and tubers was lowest in northern SSA. Total consumption of food from cereals, roots and tubers, however, almost doubled during the 1975–95 period (Table 1), reflecting the impact of rapid population growth. While total consumption of cereals increased from 33.1 million tonnes in 1975 to 61.3 million tonnes in 1995, total consumption of roots and tubers increased from 13.8 to 23.9 million tonnes within the same period.

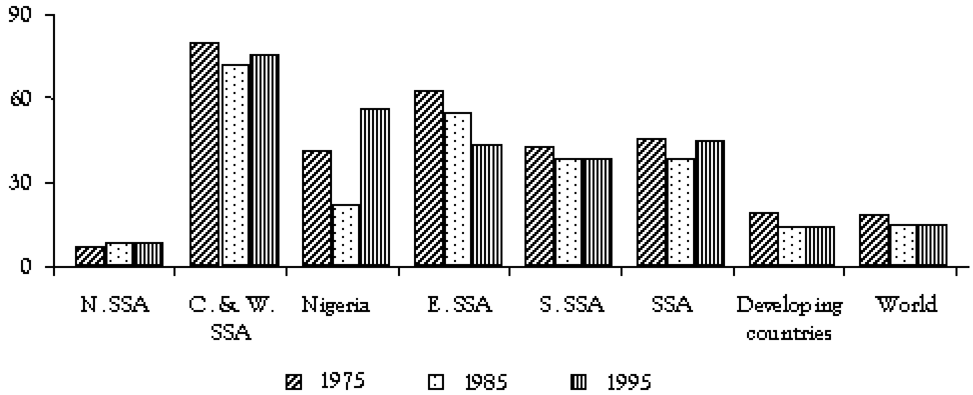


Source: Based on FAOSTAT data (FAO 2000).

Figure 1. *Consumption of milk (kg/capita), 1975–95.*

2. SSA is disaggregated into northern SSA (Burkina Faso, Chad, Djibouti, Eritrea, Ethiopia, Mali, Mauritania, Niger, Somalia and Sudan), central and western SSA (Benin, Cameroon, Central African Republic, Comoros Island, Democratic Republic of Congo, Congo Republic, Côte d'Ivoire, Gabon, The Gambia, Ghana, Guinea, Guinea Bissau, Liberia, Sao Tome and Principe, Senegal, Sierra Leone and Togo), Nigeria, eastern SSA (Burundi, Kenya, Rwanda, Tanzania and Uganda), and southern SSA (Angola, Botswana, Lesotho, Madagascar, Malawi, Mauritius, Mozambique, Namibia, Reunion, Swaziland, Zambia and Zimbabwe) to reflect the different factors constraining production systems. For example, labour is a constraining factor in central and western SSA while land is a constraining factor

in eastern SSA.



Source: Based on FAOSTAT data (FAO 2000).

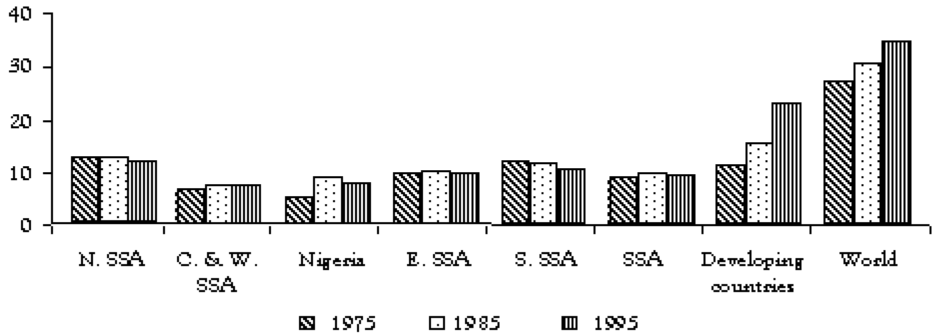
Figure 2. *Consumption of roots and tubers (dry weight equivalent: kg/capita), 1975–95.*

Table 1. *Total consumption of cereals and roots and tubers (× 10^6 t), 1975–95.*

Region	Cereals			Roots and tubers (dry weight equivalent)		
	1975	1985	1995	1975	1985	1995
N. SSA	10.1	13.3	19.2	0.6	0.9	1.2
C. & W. SSA	5.5	7.8	10.6	5.7	6.9	9.8
Nigeria	7.1	9	14	2.5	1.8	6.2
E. SSA	4.6	6.4	8.1	3.1	3.6	3.8
S. SSA	5.8	7.7	9.3	1.9	2.3	3
SSA	33.1	44.3	61.3	13.8	15.5	23.9
Developing countries	433.1	600.6	732.8	55	51.6	62.8
World	581.9	757.7	899.9	73.6	70.3	82.2
Source: Based on FAOSTAT data (FAO 2000).						

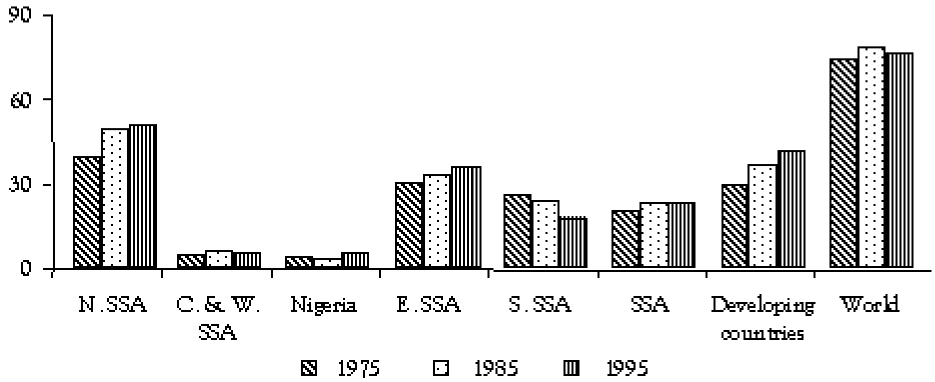
Although the average per capita consumption of meat, milk and eggs in developing countries increased substantially during the 1975–95 period, per capita consumption in SSA stagnated or declined or increased only slightly within the same period (Figures 3–5).[3] Per capita consumption of meat, milk and eggs in SSA in 1995 were only 9.5, 23.9 and 1.4 kg, respectively, which were about 27, 31 and 20% of the respective world average. Within SSA, per capita consumption of meat, milk and eggs were the lowest in central and western SSA. Total consumption of meat, milk and eggs in SSA, however, doubled between 1975 and 1995 (Table 2). For example, meat consumption increased from 2.8 million tonnes in 1975 to 5.1 million tonnes in 1995, while milk consumption shot from 6.4 to 12.9 million tonnes. This doubling of demand was fuelled by rapid population growth, similar to the consumption of cereals and roots and tubers, rather than growth in incomes. For example, between 1980 and 1995, the annual rate of population growth was a staggering 2.9%, although gross national product (GNP) per capita declined by 1.3% annually (UNDP 1998, cited in Delgado et al. 1999).

3. Meat includes beef and buffalo meat, sheep, goat, poultry and pig meat; milk is raw milk; and eggs are from hens



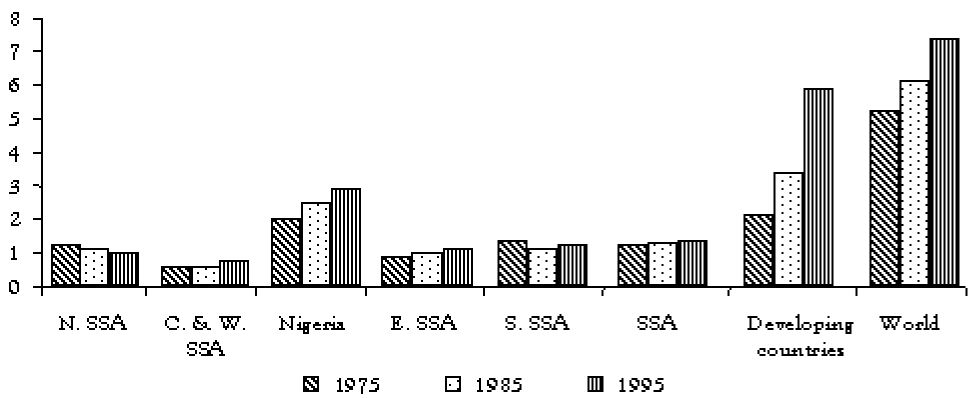
Source: Based on FAOSTAT data (FAO 2000).

Figure 3. *Consumption of meat (kg/capita), 1975–95.*



Source: Based on FAOSTAT data (FAO 2000).

Figure 4. *Consumption of milk (kg/capita), 1975–95.*



Source: Based on FAOSTAT data (FAO 2000).

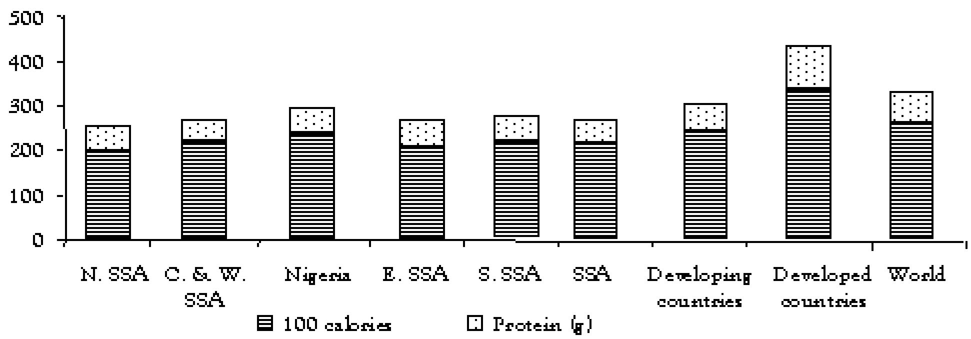
Figure 5. *Consumption of eggs (kg/capita), 1975–95.*

Table 2. T*otal consumption of meat, milk and eggs (× 10^6 t), 1975–95.*

	Meat			Milk			Eggs		
Region	1975	1985	1995	1975	1985	1995	1975	1985	1995
N. SSA	1.0	1.3	1.5	3.1	5.1	6.8	0.09	0.12	0.13
C. & W. SSA	0.5	0.7	1.0	0.4	0.6	0.8	0.04	0.06	0.1
Nigeria	0.3	0.8	0.9	0.3	0.3	0.7	0.12	0.21	0.32
E. SSA	0.5	0.7	0.9	1.5	2.2	3.2	0.04	0.07	0.1

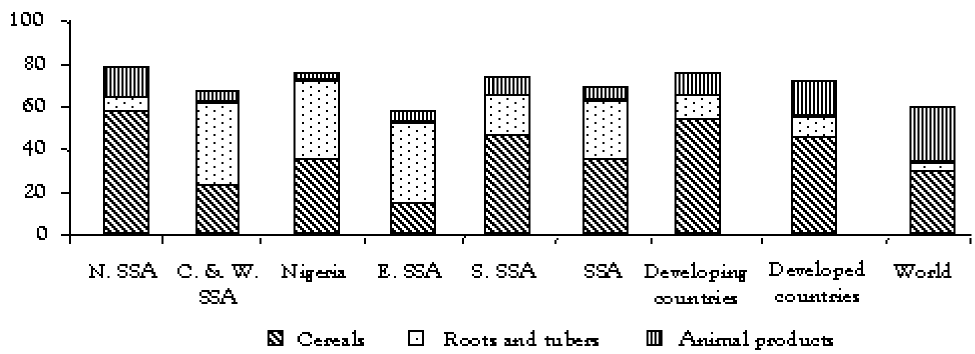
S. SSA	0.5	0.7	0.8	1.2	1.5	1.4	0.06	0.06	0.1
SSA	2.8	4.1	5.1	6.4	9.7	12.9	0.36	0.52	0.76
Developing countries	33.3	55.6	100.3	87.3	133.5	183.6	6.14	12.12	25.85
World	111.0	147.6	196.7	302.7	380.3	433.2	21.1	29.2	41.6
Source: Based on FAOSTAT data (FAO 2000).									

Consistent with the low consumption of food in SSA is the low supply of daily calories and proteins (Figure 6). Between 1975 and 1995, daily calories and protein supply averaged 2169 calories and 55 g, respectively, which were about 83 and 78% of the world averages, respectively. Within SSA, while northern SSA recorded the lowest supply of calories (1964), it recorded the highest daily supply of proteins (58 g). Central and western SSA registered the lowest daily supply of proteins. As Figure 7 shows, the contribution of cereals, roots and tubers and animal products in the diets of people vary across regions and sub-regions in SSA. Although cereals constitute the bulk of the source of calories in the entire region, roots and tubers are more important in eastern, central and western SSA, while animal products contribute significantly to calorie supply in northern SSA. In the developed world, however, cereals and animal products are equally important in supplying calories (Figure 7). With respect to protein, only in the developed world did animal products contribute a larger proportion to the total supply within the same period. In SSA as a whole, cereals contributed about 55% of the total protein supply, while animal products contributed 25%.



Source: Based on FAOSTAT data (FAO 2000).

Figure 6. *Per capita daily calorie and protein supply (average 1975–95).*

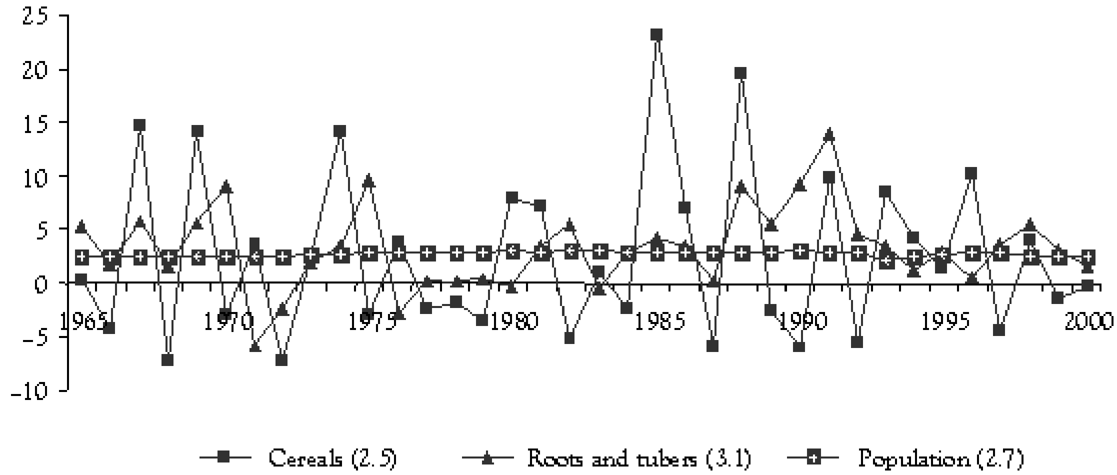


Source: Based on FAOSTAT data (FAO 2000).

Figure 7. *Percentage contribution to total daily calorie supply (average 1975–95).*

2.2 Production and trade

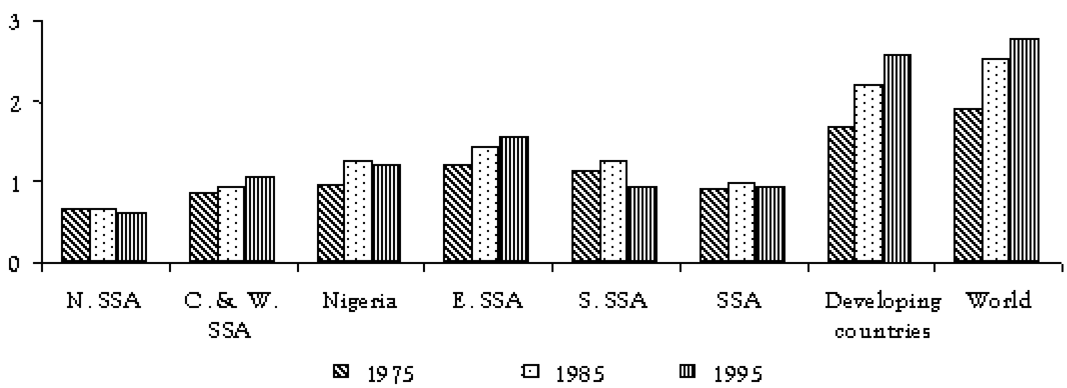
The low per capita consumption of cereals, roots and tubers and animal products in SSA is reflected by the low food productivity, production and imports to meet the demand of the rapidly growing population. For example, between 1965 and 1995, although total production of cereals grew by 2.5%, population grew by 2.7% (Figure 8). In addition, although yields of cereals and roots and tubers increased moderately between 1975 and 1995, especially with respect to roots and tubers (Figures 9 and 10), per capita production of cereals and roots and tubers declined in all the sub-regions, with the exception of Nigeria (Figures 11 and 12). Cereal yields have barely surpassed 1 t/ha. In 1995, average cereal yield in developing countries was 2.6 times higher, while yields of roots and tubers were only 62% of the average of developing countries.



Note: Average percentage change in brackets.

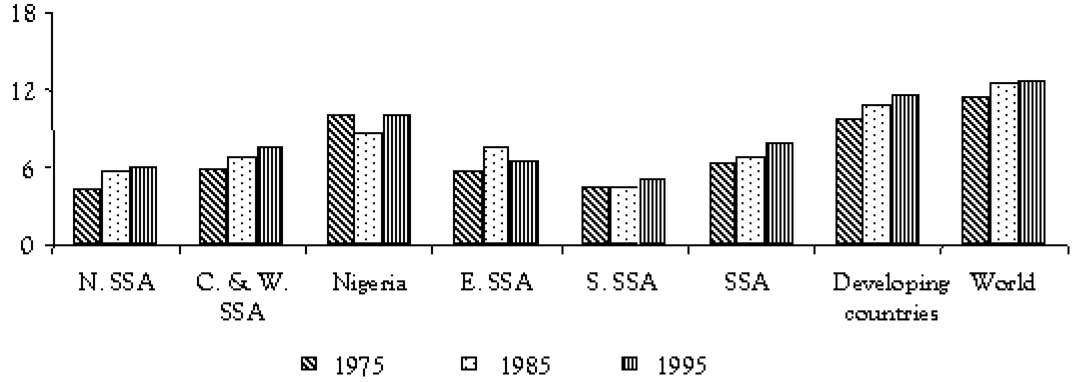
Source: Based on World Development Indicators (World Bank 2002).

Figure 8. *Production of crops (% change from previous year), 1965–2000.*



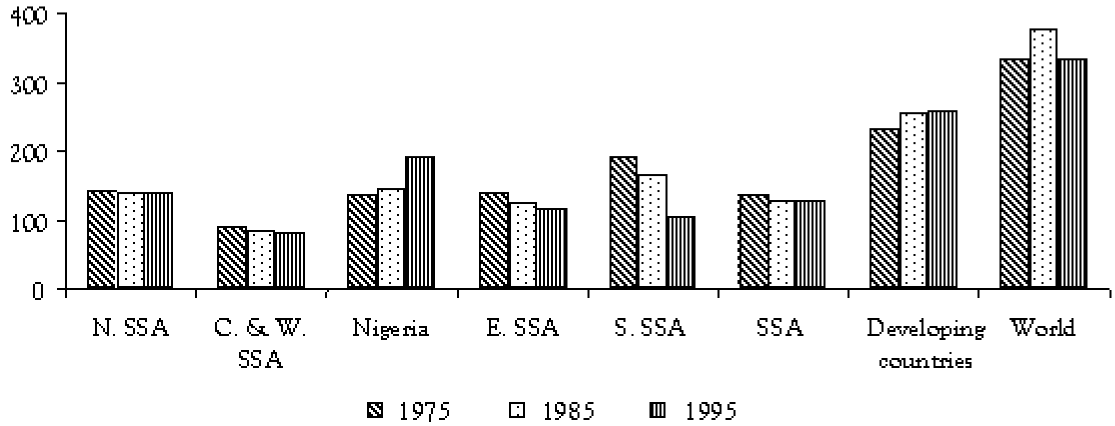
Source: Based on FAOSTAT data (FAO 2000).

Figure 9. *Average yields of cereal (t/ha), 1975–95.*



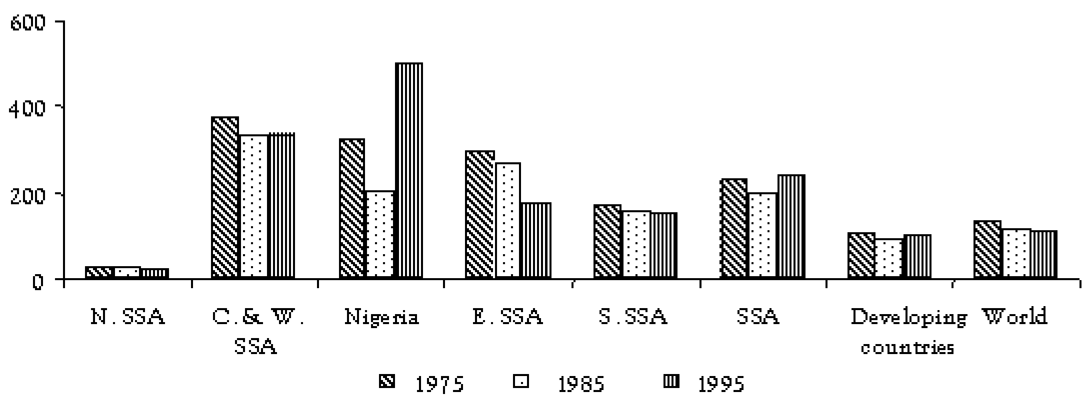
Source: Based on FAOSTAT data (FAO 2000).

Figure 10. *Average yields of roots and tubers (t/ha), 1975–95.*



Source: Based on FAOSTAT data (FAO 2000).

Figure 11. *Production of cereal (kg/capita), 1975–95.*



Source: Based on FAOSTAT data (FAO 2000).

Figure 12. *Production of roots and tubers (kg/capita), 1975–95.*

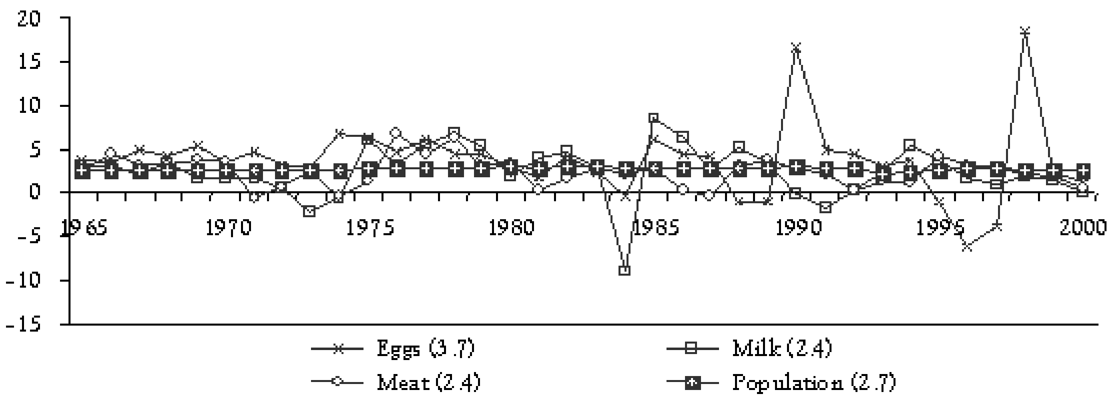
Livestock productivity in SSA has also been very low compared to other parts of the world. Beef and milk production per animal declined between 1975 and 1995 (Table 3). In 1995, while production of beef per animal was about 65% of the world average, production of milk per animal was only 14% of the world average. Similar to production of cereals, population outgrew production of both meat and milk (Figure 13).

Table 3. *Livestock productivity (yield = kg/head), 1975–95.*

Region	Beef and buffalo meat			Milk		
	1975	1985	1995	1975	1985	1995
N. SSA	122	125	112	117	122	103
C. & W. SSA	127	127	130	92	91	86
Nigeria	221	217	167	240	239	233
E. SSA	120	117	120	210	203	225
S. SSA	153	157	156	299	311	305
SSA	135	140	129	145	145	129
Developing countries	148	156	166	342	376	424
World	186	197	198	971	960	924

Source: Based on FAOSTAT data (FAO 2000).

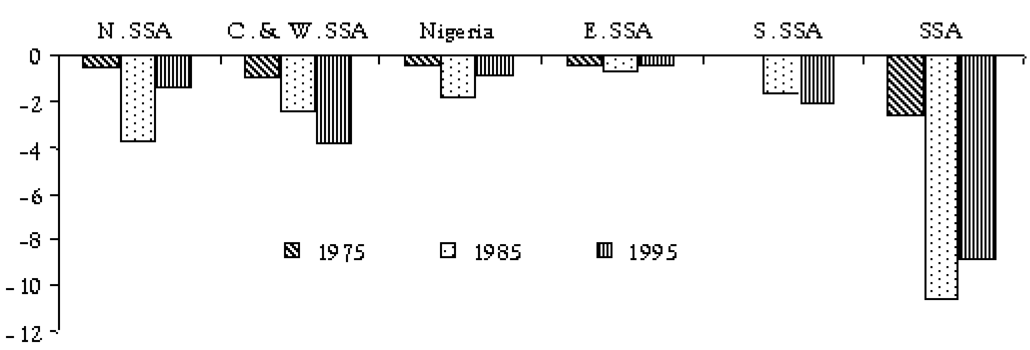
To mitigate the production–consumption gap, net imports of food have grown steadily over the years. All sub-regions in SSA were net importers of cereals between 1975 and 1995 (Figure 14). Between these two periods, net imports of cereals in the entire SSA increased by more than 200%, from 2.6 to 8.9 million tonnes, with the value in 1995 amounting to US$ 2.3 billion (Table 4). Imports of meat and milk also increased steadily over the years in all sub-regions of SSA (Table 5), with the entire SSA switching from a moderate net exporter of animal products (mainly meat) in 1975 to a net importer by 1985. Between 1975 and 1995, total values of net imports of meat, milk and eggs in SSA increased from US$ 4 to 283 million.



Notes: Average percentage change in brackets.

Source: Based on FAOSTAT data (FAO 2000).

Figure 13. *Production of livestock (% change from previous year), 1965–2000.*



Source: Based on FAOSTAT data (FAO 2000).

Figure 14. *Net trade of cereals (× 10^6 t), 1975–95.*

Table 4. *Net trade of cereals, 1975–95.*

Region	$(\times 10^6)$ t			US$ $(\times 10^6)$ t		
	1975	1985	1995	1975	1985	1995
N. SSA	–0.59	–3.79	–1.44	–133	–750	–426
C. & W. SSA	–1.04	–2.46	–3.90	–238	–495	–1039
Nigeria	–0.45	–1.96	–0.95	–99	–501	–202
E. SSA	–0.45	–0.73	–0.49	–117	–123	–75
S. SSA	–0.09	–1.70	–2.18	–101	–309	–523
SSA	–2.62	–10.63	–8.95	–688	–2178	–2265

Source: Based on FAOSTAT data (FAO 2000).

Table 5. *Net trade of meat, milk and eggs, 1975–95*.

Region	$(\times 10^3)$ t			US$ $(\times 10^6)$ t		
	1975	1985	1995	1975	1985	1995
N. SSA	4.51	–10.99	–2.78	5.5	–6.6	7.8
C. & W. SSA	–31.14	–121.41	–127.97	–38.8	–139.0	–146.5
Nigeria	–4.90	–4.50	–23.65	-6.7	–6.2	–30.1
E. SSA	4.56	0.11	0.37	4.9	0.2	0.5
S. SSA	29.22	–44.46	–82.17	39.4	–56.3	–114.3
SSA	2.34	–181.25	–236.30	4.2	–207.9	–282.6

Source: Based on FAOSTAT data (FAO, 2000).

In the next section, we look at the 2020 projections of food demand, production, trade and utilisation indicators (e.g. daily calorie supply and child malnutrition) under different policy, economic, social and demographic contexts.

3 Projections of food demand and supply to 2020

3.1 The 2020 baseline assumptions

3.2 Projections to 2020 under baseline assumptions

3.3 Projections to 2020 under alternative scenarios

- 3.3.1 Impacts of slower population growth
- 3.3.2 Impacts of higher livestock productivity
- 3.3.3 Full trade liberalisation
- 3.3.4 Pessimistic scenario
- 3.3.5 Optimistic scenario

The International Food Policy Research Institute's (IFPRI) International Model for Policy Analysis of Agricultural Commodities and Trade (IMPACT) (Rosegrant et al. 2001), a methodology for analysing alternative scenarios for global and regional food demand, supply and trade, was used to project the 2020 food demand, supply, trade and utilisation in SSA. IMPACT represents a competitive agricultural market for crops and livestock. The model is specified as a set of country or regional sub-models, where demand, supply and prices are determined in each model. The separate models are linked through trade, highlighting the interdependence of countries/regions and commodities in global agricultural markets. IMPACT uses a system of supply and demand elasticities, which are incorporated into a series of linear and non-linear equations to approximate the underlying production and demand functions. Each year, world agricultural commodity prices are determined at levels that clear national markets. Demand is a function of prices, income and population growth, while growth in production is determined by prices and growth in productivity.

Although the IMPACT simulation covered 36 countries and regions and 16 commodities, the discussion in this paper focuses on SSA and major food commodities: cereals, roots and tubers, meat, milk and eggs (see Appendix for list of sub-regions, countries and commodities). All simulations in this study begin from a base year of 1997, with data extracted from the FAOSTAT database (FAO 2000). The key parameters with potentially significant effect on the projections include price and income elasticities of demand and supply, population growth rates, urbanisation, income, and crop and livestock yield and production, and growth in investments in irrigation, rural access roads, education, clean water, agricultural research etc.

3.1 The 2020 baseline assumptions

The baseline assumptions about growth from the 1997 level of some of the major drivers in the projections are shown in Table 6. One of the major factors affecting the projections relate to agricultural area and productivity. Projected growth in these factors between 1997 and 2020 are consistent with historical trends, taking into consideration potential cultivable land, conversion of agricultural land for urban needs and public investment in agricultural research and rural infrastructure. Although productivity has been low and stagnant in SSA, a significant portion of the world's remaining high- potential arable land lies within the region, especially western, central and southern SSA. Compared to other regions, SSA can thus expect modest increase (at a declining rate) in agricultural area between 1997 and 2020. Total area under cereals and roots and tubers are assumed to increase by about 25%, while average yields are assumed to increase by one-half. The number of slaughtered cattle, milking cows and egg layers are assumed to increase by more than 50%.

Table 6. *Baseline assumptions for projections to 2020 for sub-Saharan Africa.*

Item	1997	2020	1997–2020
Agricultural production factors			
Cereal yield (kg/ha)	948	1380	n.a.
Cereal area (× 10^3) ha	73,136	93,151	n.a.
Roots and tubers yield (kg/ha)	7876	11,645	n.a.
Roots and tubers area (× 10^3 ha)	17,769	21,637	n.a.
Beef and buffalo yield (kg/head)	128	164	n.a.
Number of slaughtered cattle (× $10^{3)}$	19,264	31,487	n.a.
Milk yield (kg/head)	132	187	n.a.
Number of milking cows (× 10^3)	120,336	179,425	n.a.
Egg yield (kg/head)	3	3	n.a.
Number of egg layers (× 10^6)	342,729	597,012	n.a.
GDP growth rate (%/year)	n.a.	n.a.	3.6
Population (× 10^6)	561	959	n.a.
Income demand elasticity			
Cereals	0.30–0.50	0.26–0.49	n.a.
Roots and tubers	0.26–0.42	0.18–0.40	n.a.
Meat	0.33–0.84	0.21–0.72	n.a.
Milk	0.73	0.61	n.a.
Eggs	0.46	0.31	n.a.
Own price yield elasticity			
Cereals	n.a.	n.a.	0.14–0.19
Roots and tubers	n.a.	n.a.	0.14–0.16
Meat	n.a.	n.a.	0.22–0.30
Milk	n.a.	n.a.	0.38
Eggs	n.a.	n.a.	0.28
Investment (US$× 10^9)	n.a.	n.a.	106.9
Irrigation	n.a.	n.a.	28.1
Rural access roads	n.a.	n.a.	37.9
Agricultural research	n.a.	n.a.	8.0
Education	n.a.	n.a.	15.7
Clean water	n.a.	n.a.	17.3
Note: n.a. means not applicable. Source: Adapted from Rosegrant et al. (2001).			

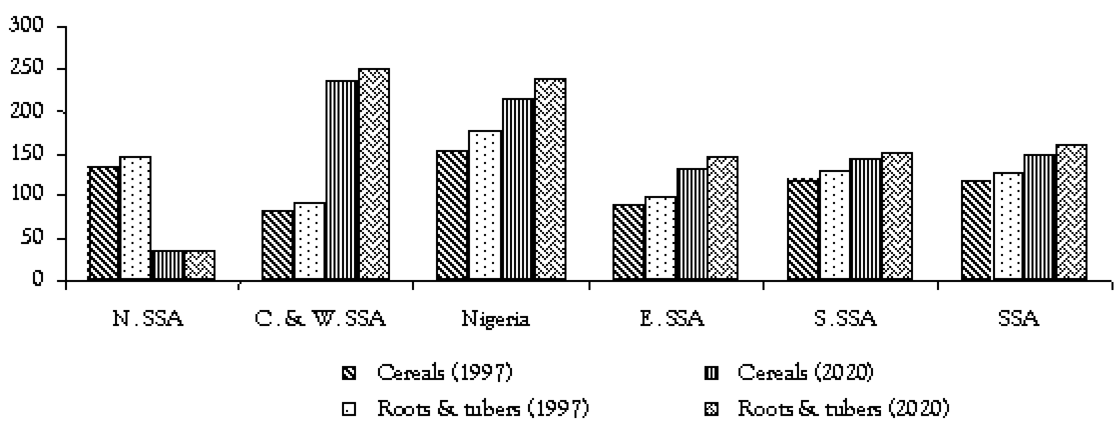
Although GDP (dominated by agriculture) growth rates in SSA have been dismal over the last four decades, there seem to be improvements recently. For example, in the 1980s only three countries (Benin, Guinea Bissau and Togo) had annual agricultural growth rates exceeding 4%. Between 1990 and 1998, nine countries (Burkina Faso, Benin, Cameroon, Chad, Guinea, Guinea-Bissau, Equatorial Guinea, Lesotho, Malawi, Mauritania, Mozambique and Togo) had joined this group (World Bank 2000). Given these improvements, GDP per capita is projected to grow at an annual rate of 3.6% between 1997 and 2020, with central and western SSA and Nigeria growing the fastest, 3.8% per annum.

The population of SSA, estimated at 561 million in 1997, is expected to grow at 2.4% per annum to reach 959 million in 2020. Based on World Bank estimates this is an outcome of modelling the growth rate over separate five-year periods, where the rates decline in the later periods as projected for other parts of the world. Related to population and income changes is urbanisation, which encourages a shift away from coarse grains and roots and tubers towards higher consumption of high-value animal products, as the price and income elasticities for livestock products among urban dwellers are generally higher (and projected to remain higher) than those for food crops (see Rosegrant et al. 2001). Projected income elasticities for livestock products range from 0.2 (for sheep and goat meat) to 0.7 (for beef), while those for cereals range from 0.3 to 0.5, and those for roots and tubers range from 0.2 to 0.4. Generally, there will be greater incentive to farmers for generating higher yields at higher prices. However, yield elasticities with respect to own prices will be higher for livestock products (0.22 to 0.38), compared to crops (0.14 to 0.19). Although, higher wages and interest rates will reduce the incentive to farmers for generating higher yields, the impacts of capital will be substantially smaller than the impacts of labour.

Substantial investments in irrigation, rural access roads, education, clean water and agricultural research are also needed. Between 1997 and 2020, total investment in these areas is projected at US$ 107 billion, representing 19% a year of government spending of US$ 25 billion in 1997. Rural access roads and irrigation attract the largest shares of the total investment of 35 and 26%, respectively. Investments in clean water and education take up 16 and 15%, respectively, and the remaining 8% goes to national agricultural research.

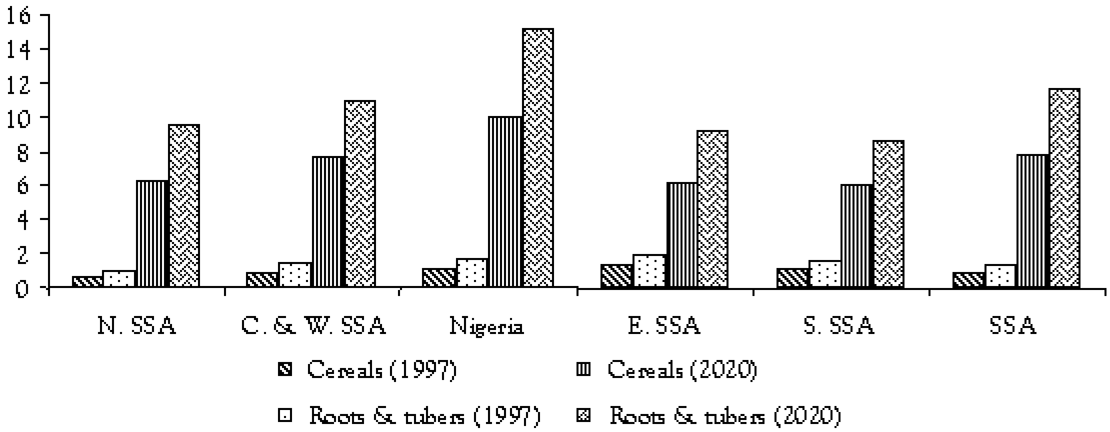
3.2 Projections to 2020 under baseline assumptions

On average, per capita consumption of cereals and roots and tubers in SSA are projected to increase by 10 and 7% over the levels in 1997 to reach 128 and 160 kg, respectively, by 2020 (Figure 15). Note, however, that increase in total consumption of cereals and roots and tubers will be between 71 and 99% in different sub-regions (Table 7), with the projected total consumption of cereals in central and western SSA almost doubling. Average yields of cereals and roots and tubers will increase by one-half (Figure 16). Net imports of cereals will more than double in the entire region by 2020 (Figure 17). However, SSA will become a net exporter of roots and tubers, with central and western SSA being the only net exporters. Total production of cereals and roots and tubers will almost double (Table 8). Nigeria and northern SSA will continue being the leading producers of cereal, while Nigeria and central and western SSA will lead production of roots and tubers.



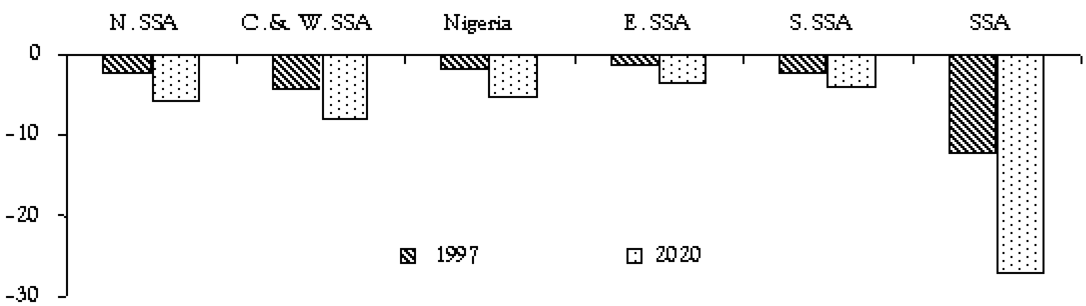
Source: IMPACT projections, June 2001.

Figure 15. *Projections of consumption of food crops (kg/capita), 1997–2020 (baseline).*



Source: IMPACT projections, June 2001.

Figure 16. *Projections of average crop yields (t/ha), 1997-2020 (baseline).*



Source: IMPACT projections, June 2001.

Figure 17. *Projections of net trade of cereals (× 10^6 t), 1997–2020 (baseline).*

Table 7. *Projections of total consumption of food crops (× 10^3 t), 1997–2020 (baseline).*

Region	Cereals		Roots and tubers	
Region	1997	2020	1997	2020
N. SSA	19,295	37,021	4839	8931
C. & W. SSA	11,328	22,542	32,530	61,231
Nigeria	15,857	29,621	22,404	40,067
E. SSA	8399	15,376	12,288	22,583
S. SSA	9960	17,684	12,057	20,575
SSA	64,841	122,243	84,117	153,387

Source: IMPACT projections, June 2001.

Table 8. *Projections of total production of food crops (× 10^3 t), 1997–2020 (baseline).*

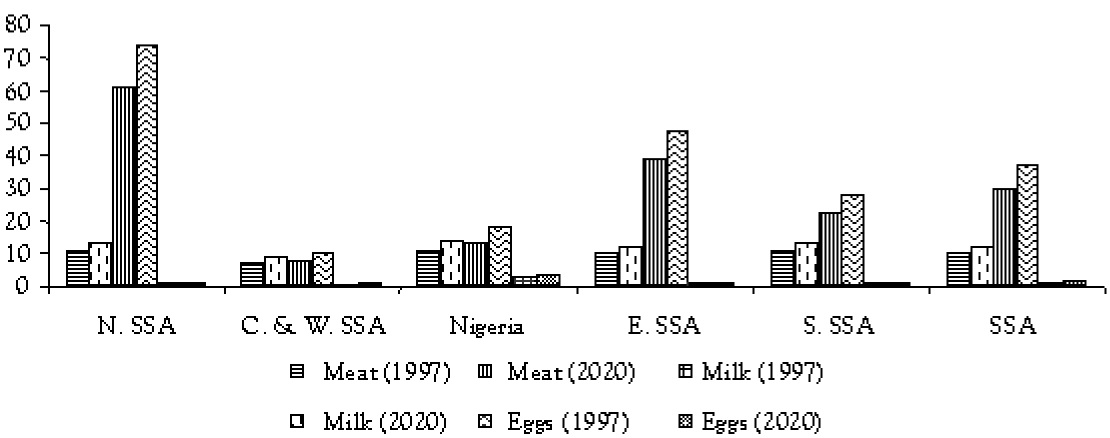
Region	Cereals		Roots and tubers	
Region	1997	2020	1997	2020
N. SSA	20,532	37,658	5458	9906
C. & W. SSA	9417	19,733	45,397	85,229
Nigeria	20,608	37,260	58,348	102,475

E. SSA	8967	16,318	16,049	29,894
S. SSA	9779	17,557	14,694	24,387
SSA	69,303	128,528	139,946	251,959

Source: IMPACT projections, June 2001.

Per capita consumption of meat, milk and eggs in SSA is expected to grow modestly and reach 12, 37 and 1.5 kg, respectively, by 2020 (Figure 18). These figures are still low, as they stand at less than 40% of the respective projected world averages. The projections for central and western SSA are the lowest within the sub-continent. Total consumption of meat and milk for the entire SSA, however, will more than double between 1997 and 2020 to reach 11.3 and 35.4 million tonnes, respectively (Table 9). The projected low per capita consumption of livestock products in SSA is due to the projected low per capita income in the region while the high projected aggregate consumption levels are driven by the expected high population growth rate. Thus, unlike the Asian countries where high expected per capita growth of 4-6% per annum will fuel the projected high per capita meat and milk consumption (see Delgado et al. 1999), in SSA, the dynamics of the structural changes in meat and milk markets will be constrained by expected limited growth in income levels.

Total production of meat, milk and eggs will double by 2020 (Table 10), while yields and per capita production will increase moderately, with only eastern SSA realising significant increment in productivity of eggs. SSA will remain a net importer of meat and milk, with central and western SSA and Nigeria in the forefront (Figure 19).



Source: IMPACT projections, June 2001.

Figure 18. *Projections of consumption of livestock (kg/capita), 1997–2020 (baseline).*

Table 9. *Projections of total consumption of meat, milk and eggs (× 10^3 t), 1997–2020 (baseline).*

Region	Meat		Milk		Eggs	
Region	1997	2020	1997	2020	1997	2020
N. SSA	1633	3286	8761	18,732	138	272
C. & W. SSA	972	2106	1075	2531	108	217
Nigeria	1095	2279	1321	3059	301	577
E. SSA	913	1860	3597	7276	104	192
S. SSA	893	1720	1860	3753	105	180
SSA	5505	11,252	16,615	35,351	755	1438

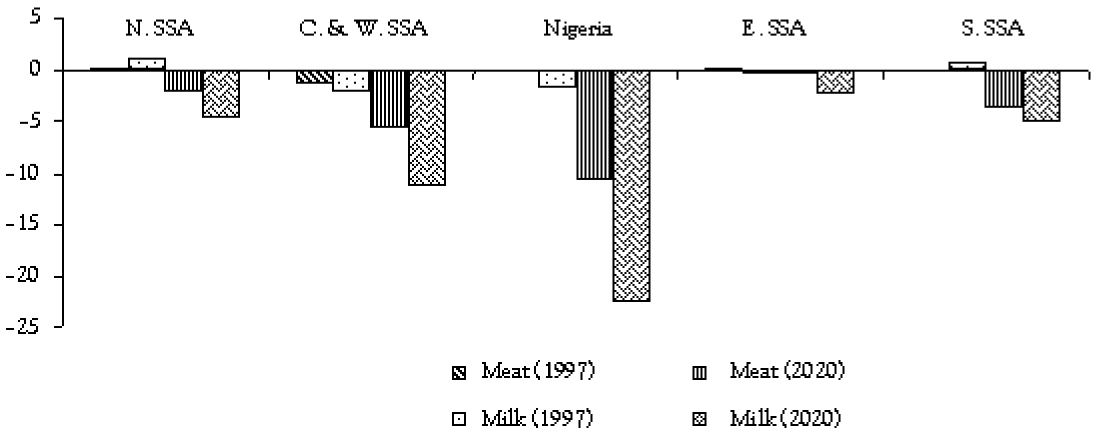
Source: IMPACT projections, June 2001.

Table 10. *Projections of total production of meat, milk and eggs (× 10^3 t), 1997–2020 (baseline)*.

Region	Meat		Milk		Eggs	
Region	1997	2020	1997	2020	1997	2020
N. SSA	1648	3381	9433	20,124	171	340
C. & W. SSA	846	1893	585	1554	136	282
Nigeria	1087	2098	366	924	341	655
E. SSA	913	1805	3742	7410	124	232
S. SSA	914	1781	1701	3507	128	218
SSA	5407	10,958	15,826	33,519	901	1727

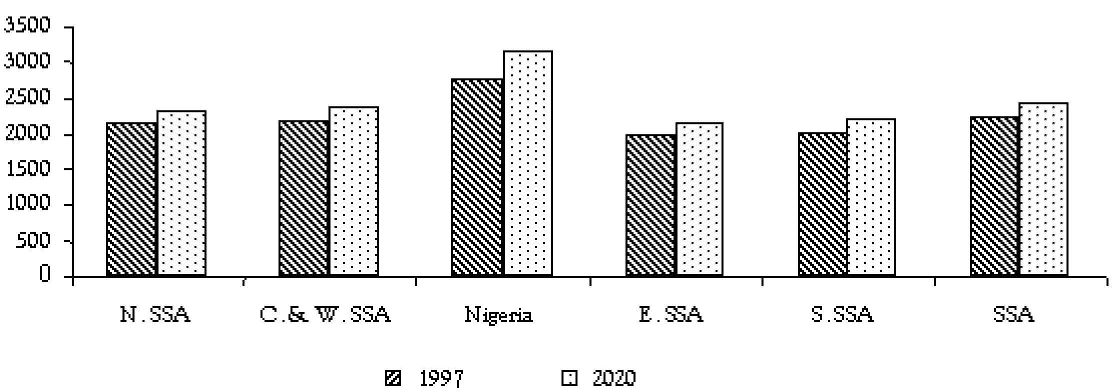
Source: IMPACT projections, June 2001.

In terms of food utilisation, total daily calories supply in SSA will increase to reach 2442 per capita, about 10% more than the level in 1997 (Figure 20). Although the number of malnourished children under the age of five in developing countries is projected to decline by 21%, the number in SSA is projected to increase by 20% (or 6.7 million children), with most of the increases taking place in northern SSA (Figure 21). Note, however, that the share of malnourished children from the total children will decline by 10% in the entire SSA.



Source: IMPACT projections, June 2001.

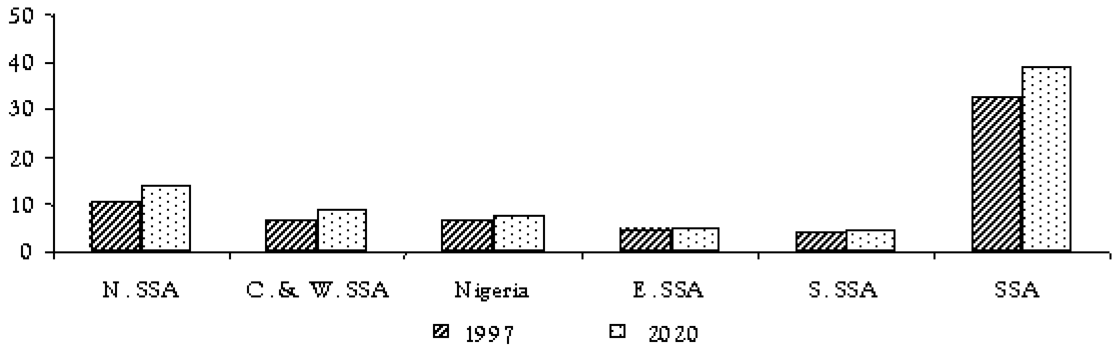
Figure 19. *Projections of net trade of meat and milk (× 10^5 t), 1997–2020 (baseline).*



Source: IMPACT projections, June 2001.

Figure 20. *Projections of daily calorie supply, 1997–2020 (baseline).*

Together, these results in projected growth in food consumption and supply will still leave SSA far behind Asia and other developing countries. Production will barely keep pace with population growth and consumption of meat and milk will be low. The share of malnourished children will reduce, although their absolute numbers will rise.



Source: IMPACT projections, June 2001.

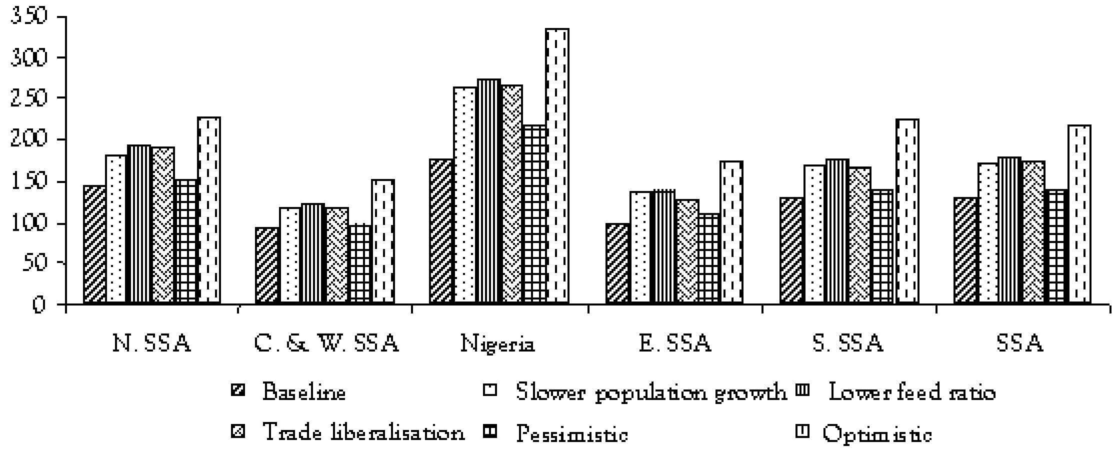
Figure 21. *Projections of number of malnourished children (×10^6), 1997–2020 (baseline).*

3.3 Projections to 2020 under alternative scenarios

The discussion above on the outlook on the future were based upon fundamental assumptions with respect to price and income elasticities of demand and supply, growth rates of population, urbanisation, income, crop and livestock productivity, and investments in irrigation, rural access roads, education, clean water and national agricultural research. In SSA, since many countries face major economic crisis and political instability, as well as HIV/AIDS epidemic, the projections for the future seem less certain compared to other developing countries and the developed world. Therefore, it is prudent to examine the projections under alternative scenarios, both pessimistic and optimistic. We believe that there are three factors having significant impact on food security: 1) demographics; 2) technical change, productivity and environmental degradation; and 3) policy (especially trade). For simplicity, we first look at the impacts of slower population growth, higher livestock productivity (through lower feeding ratios) and full trade liberalisation separately on the future food demand, production, trade and utilisation. Then, we examine the impacts of combined changes in the 2020 baseline assumptions or general pessimistic and optimistic growth rates in agricultural productivity and investments. The following analyses look at the differences between the projections under the 2020 baseline scenario as discussed earlier and the projections under the alternative scenarios. Detailed results of these analyses are presented in Figures 22 to 36 and Table 11.

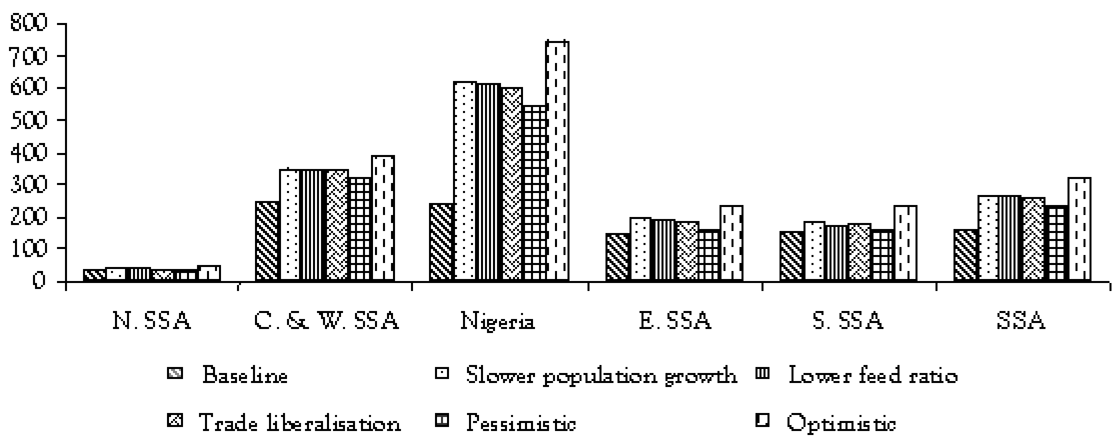
3.3.1 Impacts of slower population growth

The impacts of population growth on food demand are fairly clear. On the supply side, the effects can be manifested through the size and composition of the work force, speed of technical innovation and change, or extent of environmental degradation (Srinivasan 1988). Using the UN low population growth rate estimates and assuming 45 million (5%) less people by 2020 in SSA, projected increase in per capita consumption of cereal will be close to 34% (or 171 kg) over the baseline figure of 128 kg, increase in per capita consumption of roots and tubers will be 50% more, while increase in meat, milk and eggs consumption per person will be 5–7% more (Figures 22–25). Production of crops and livestock will decline by up to 4% (Figures 26–29). Slower population growth has a relative smaller impact on prices (Figure 30) and trade (Figures 31–34). However, the increased consumption will raise the daily calorie supply to 2530 calories per capita (Figure 35), and reduce the number of malnourished children by 5.6 million (14%; Figure 36).



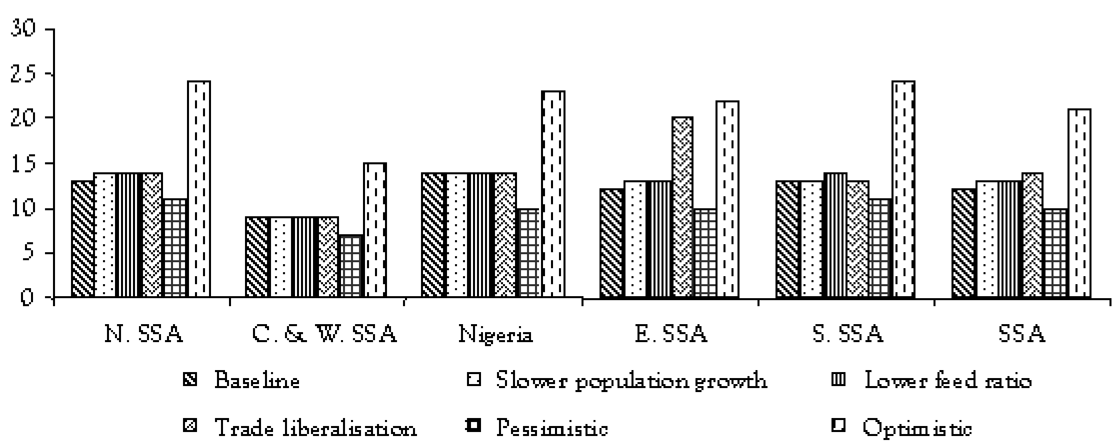
Source: IMPACT projections, June 2001.

Figure 22. *Projections of cereal consumption (kg/capita), alternative 2020 scenarios.*



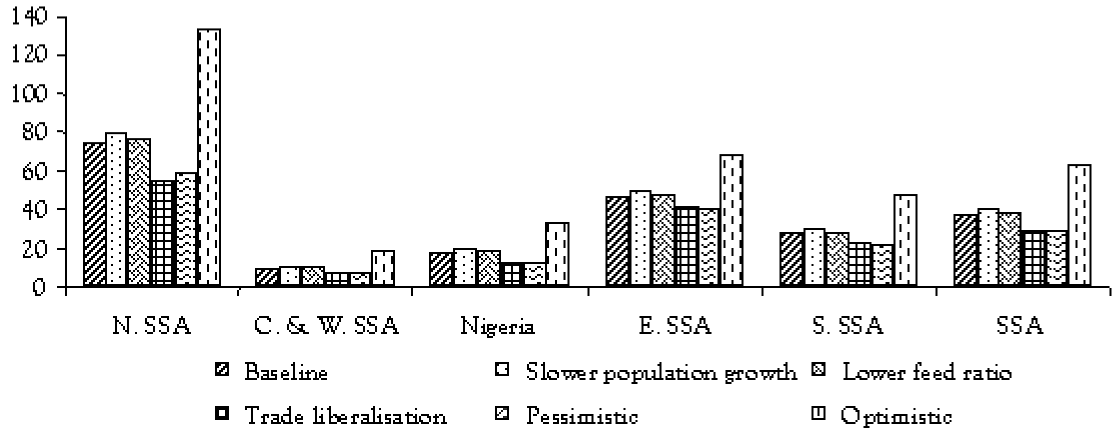
Source: IMPACT projections, June 2001.

Figure 23. *Projections of roots and tubers consumption (kg/capita), alternative 2020 scenarios.*



Source: IMPACT projections, June 2001.

Figure 24. *Projections of meat consumption (kg/capita), alternative 2020 scenarios.*

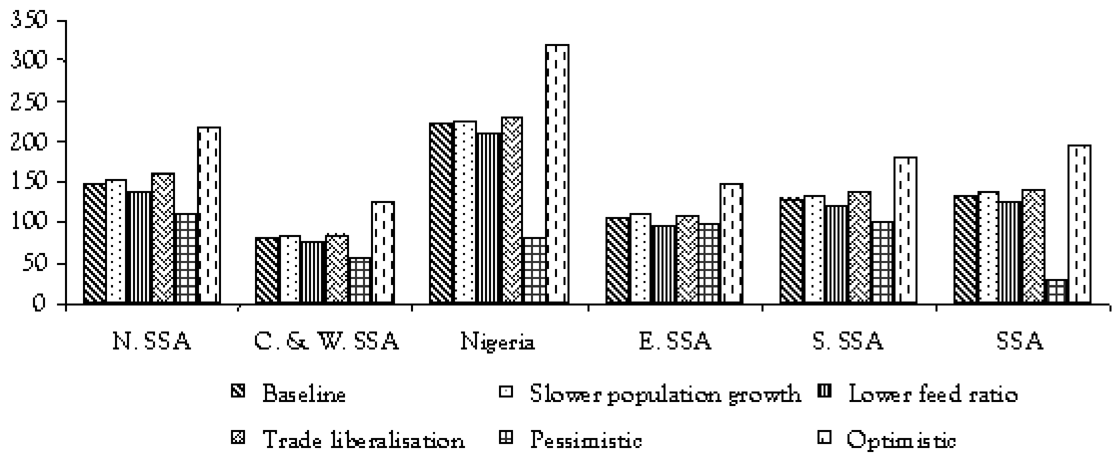


Source: IMPACT projections, June 2001.

Figure 25. *Projections of milk consumption (kg/capita), alternative 2020 scenarios.*

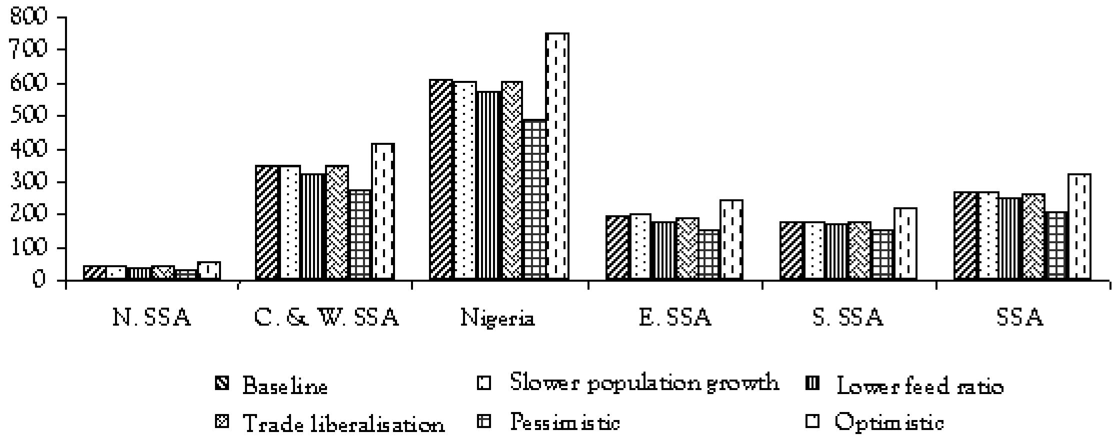
3.3.2 Impacts of higher livestock productivity

Assuming higher livestock productivity through lower feeding ratios, world prices of grain and livestock will fall (Figure 30), boosting food (grain and livestock) demand worldwide particularly in SSA. On average, increase in per capita consumption of cereals and roots and tubers will be 39 and 64%, respectively, while increase in per capita consumption of meat and milk will be 3% (Figures 25 and 26). Daily calorie supply will grow to 2559 (or 5% increase), while the number of malnourished children will drop by 1.6 million (or 4%). The lower feed ratio has a notable impact on trade patterns, particularly crops (Figures 31 and 32). Net imports of cereals and roots and tubers increase sharply as the low food prices stimulate food demand. On average, net cereal imports increase by 8%, while SSA goes from a modest net exporter of root and tubers (0.1 million tonne) to a massive net importer (17 million tonnes).



Source: IMPACT projections, June 2001.

Figure 26. *Projections of cereal production (kg/capita), alternative 2020 scenarios.*

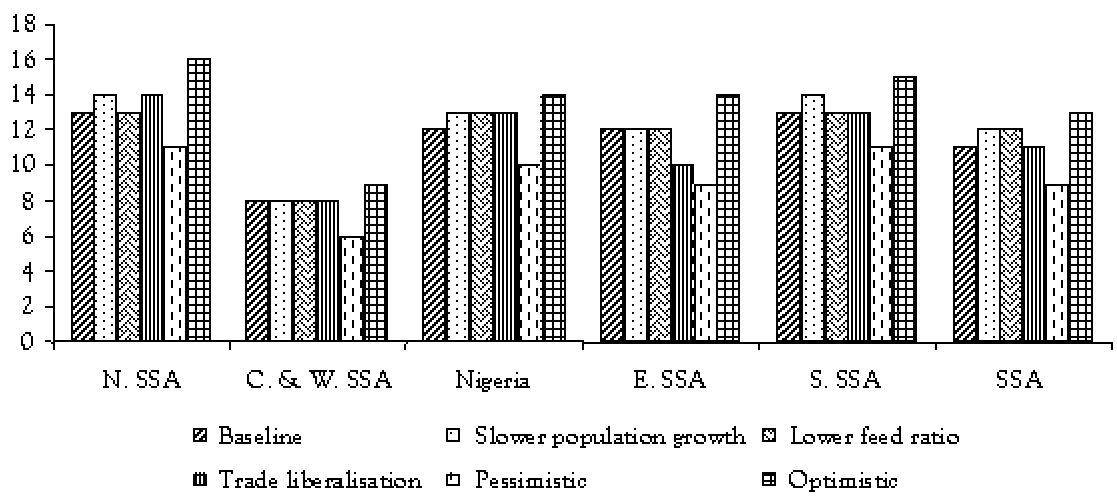


Source: IMPACT projections, June 2001.

Figure 27. *Projections of roots and tubers production (kg/capita), alternative 2020 scenarios.*

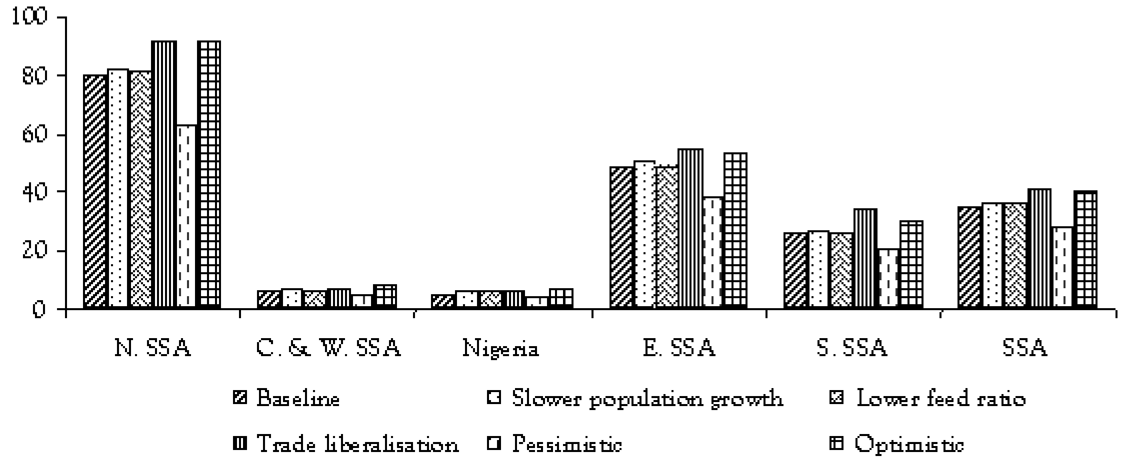
3.3.3 Full trade liberalisation

With full trade liberalisation, i.e. removal of all agricultural subsidies and trade barriers in food markets for the commodities included in the model, world prices of grain and livestock products increase, with the increments being higher for livestock, as meat prices seem to be more distorted. Surprisingly, the impact is less on livestock producers and consumers than on grain producers and consumers. Meat production in the entire SSA only falls by 1%, although it falls by 11% in eastern SSA and increases moderately (by 2–3%) in northern and southern SSA. Although higher milk prices induce production to increase by 18%, it reduces consumption by 22%. Higher crop prices will boost both production and consumption, with consumption of cereals increasing by 35%. The impacts on daily calorie supply and child malnutrition are small, compared to the slower population growth and lower feed ratios scenarios. Daily calorie supply increases by only 2%, while child malnutrition is reduced by 0.6 million (or 2%). Trade patterns are affected significantly, although the impacts on cereals and roots and tubers across the sub-regions are mixed, with slight increases for the entire SSA. The higher prices stimulate imports of meat and exports of milk, with SSA going from a net importer of milk (4.6 million tonnes) in the baseline scenario to a net exporter (9.7 million tonnes).



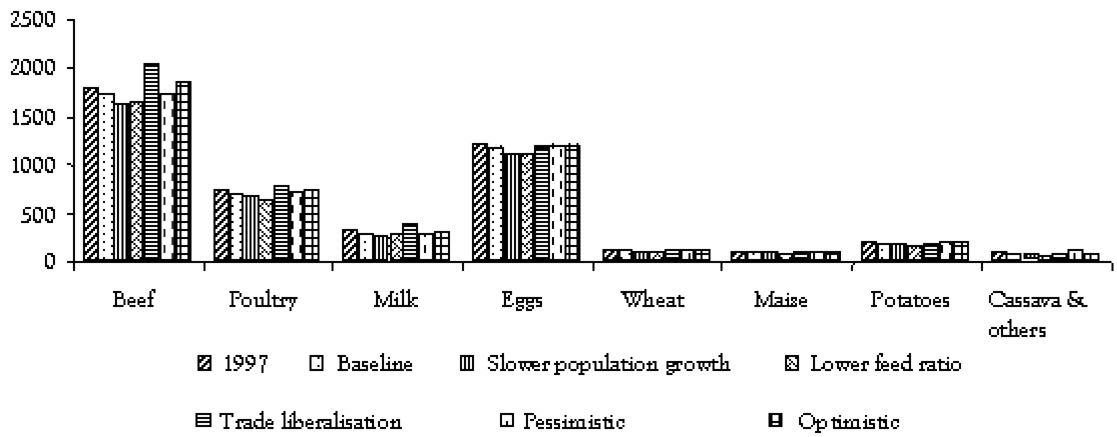
Source: IMPACT projections, June 2001.

Figure 28. *Projections of meat production (kg/capita), alternative 2020 scenarios.*



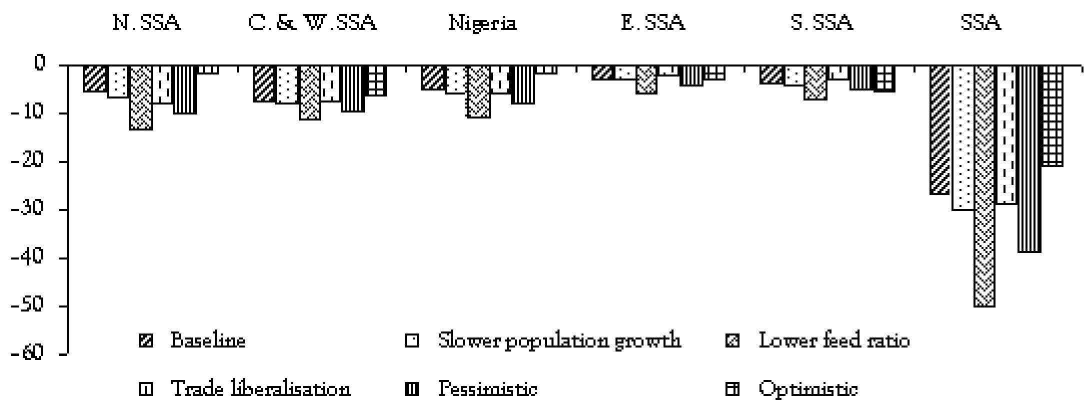
Source: IMPACT projections, June 2001.

Figure 29. *Projections of milk production (kg/capita), alternative 2020 scenarios.*



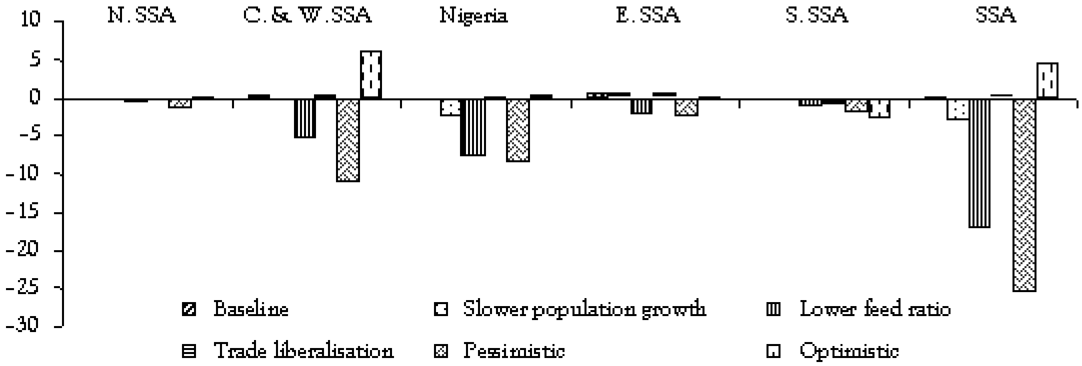
Source: IMPACT projections, June 2001.

Figure 30. *Projections of world prices of selected commodities, alternative 2020 scenarios.*



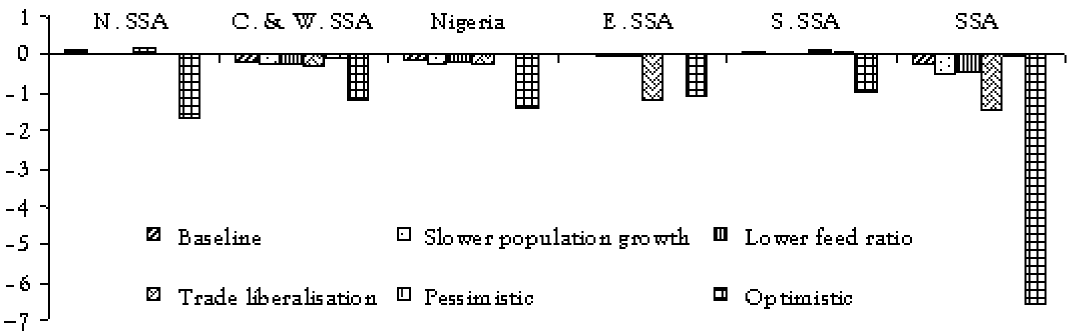
Source: IMPACT projections, June 2001.

Figure 31. *Projections of net trade of cereal (× 10^6 t), alternative 2020 scenarios.*



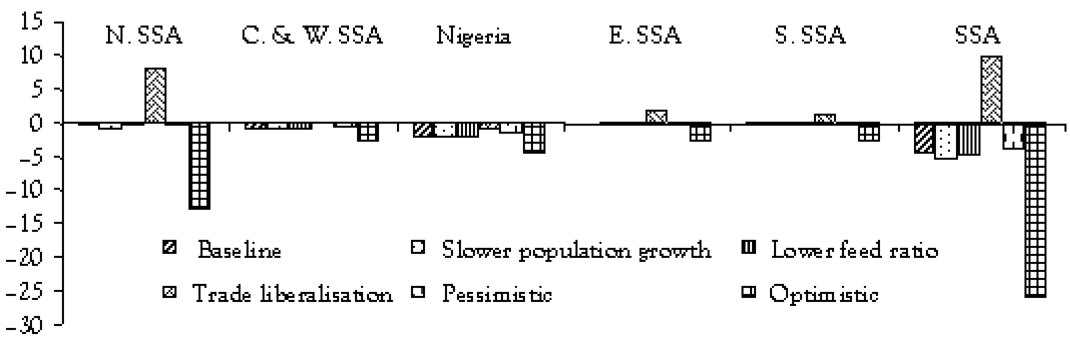
Source: IMPACT projections, June 2001.

Figure 32. *Projections of net trade of roots and tubers* (× 10[6]) *t, alternative 2020 scenarios.*



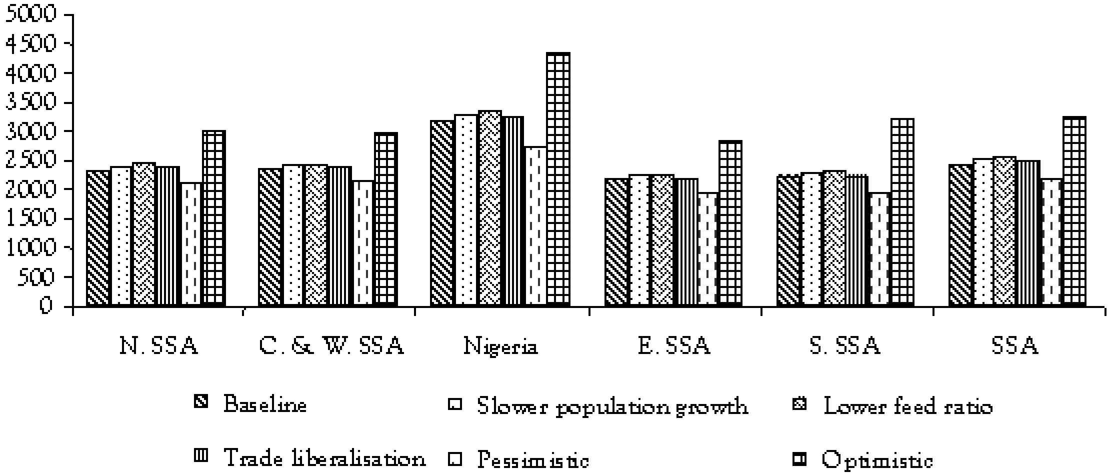
Source: IMPACT projections, June 2001.

Figure 33. *Projections of net trade of meat (× 10^6) t alternative 2020 scenarios.*



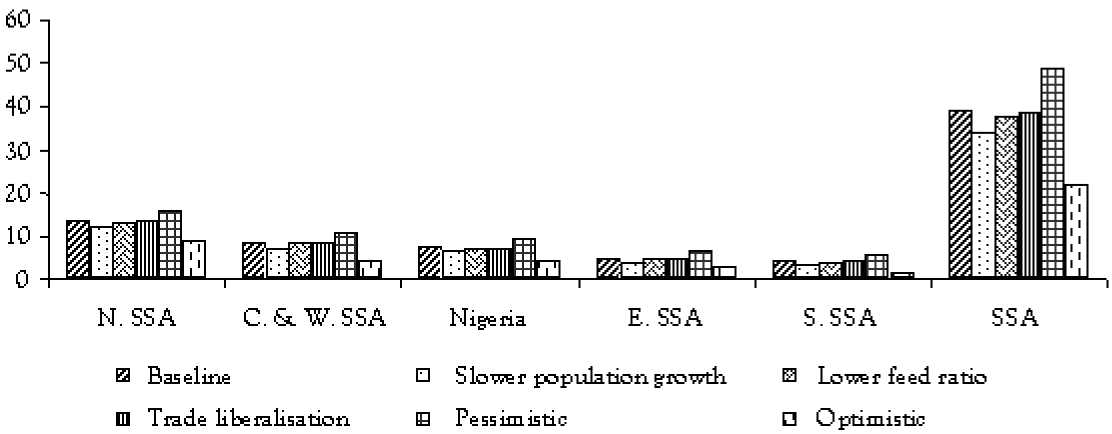
Source: IMPACT projections, June 2001.

Figure 34. *Projections of net trade of milk (× 10^6) t alternative 2020 scenarios.*



Source: IMPACT projections, June 2001.

Figure 35. *Projections of daily calorie supply, alternative 2020 scenarios.*



Source: IMPACT projections, June 2001.

Figure 36. *Projections of number of malnourished children (× 10^6), alternative 2020 scenarios.*

Table 11. *Assumptions for sub-Saharan Africa under pessimistic and optimistic scenarios to 2020.*

Item	Baseline	Optimistic	Pessimistic
Change from 2020 baseline (%)			
Cereal yield	n.a.	100	–50
Cereal area	n.a.	0	–50
Roots and tubers yield	n.a.	50	–50
Roots and tubers area	n.a.	0	–50
Livestock yield	n.a.	0	–30
Livestock area	n.a.	30	–30
Schooling	n.a.	20	–10
Sanitation	n.a.	10	–10
Life expectancy	n.a.	10	–4
GDP growth rate (%/year)	3.5	8	1.8
Investment (US$ × 109)	106.9	182.8	55.8

Irrigation	28.1	54.4	0
Rural access roads	37.9	56.3	21.8
Agricultural research	8	14.1	5.1
Education	15.7	37.2	12.9
Clean water	17.3	20.7	15.3

Note: n.a. means not applicable.

Source: Adapted from Rosegrant et al. (2001).

With the exception of cereal consumption, which increased significantly, it seems that there were not much differences in the consumption and production of food between the baseline and the three separate scenarios. Although full trade liberalisation had the most positive impact on meat consumption, especially in eastern SSA, it fared the worst in the consumption of milk. Furthermore, with the exception of net trade of milk, net trade of cereals, roots and tubers and meat increased in all the three scenarios.

The following couple of experiments are more general, where we alter a broad range of policy-sensitive variables (of baseline assumptions) that affect food security and are subject to some degree of uncertainty. Basically, we try to analyse the impacts of alternative strategies such as a more aggressive public investment in improving agriculture or cutting back on public investment. Table 11 summarises the changes in the 2020 baseline assumptions.

3.3.4 Pessimistic scenario

Crop area and yields and livestock growth are reduced by 50 and 30%, respectively. Growth in GDP is reduced by 50% and several social indicators are also allowed to worsen (e.g. education and sanitation falls by 10% and life expectancy falls by 4%). In addition, public investments are reduced by 50%, without any investment in irrigation. This general pessimistic scenario adversely affects overall agricultural production and food security. Production of cereals, root and tuber crops and livestock products will drop by 18–26%. With low incomes, a shift in the consumption from animal products to food crops becomes apparent with the consumption of livestock products falling by 6–27%, while the consumption of food crops increases. Low incomes also induce SSA to cut back on imports of meat, milk and eggs, however, net imports of food crops will increase to unsustainable levels in an effort to mitigate the production–consumption gap. Total daily calorie supply will fall below the 1997 level to 2162 per capita, and the number of malnourished children will increase by 9.3 million (or 24%).

3.3.5 Optimistic scenario

The 2020 baseline projections reveal that SSA would be far behind other developing countries. Thus, this optimistic scenario presents what it will take for SSA to reach the level of other developing countries under the baseline projections. Specifically, what are the requirements in SSA necessary to raise daily calorie supply to 3232 per capita and reduce the number of malnourished children to 22 million (see Rosegrant et al. 2001). To meet these targets, cereal yield has to double by 2020, yield of roots and tubers has to increase by one-half and livestock area has to increase by 30% without any increase in productivity (Table 11). In addition, GDP has to grow at 8% annually, female schooling should increase by 20% and sanitation and life expectancy should increase by 10%. Furthermore, total public investments in irrigation, rural access roads, education, clean water and agricultural research should increase by 71% to reach US$ 183 billion. Food consumption, production and trade under this scenario are shown in Figures 22–34. Food production is much higher. On average, consumption of cereals is 70% higher than the 2020 baseline scenario, consumption of roots and tubers is double, consumption of meat and milk is 73% higher and consumption of eggs is 41% higher. Production of food crops and livestock products is up to 46% higher. Net imports of meat, milk and eggs are higher, while net exports of cereal and roots and tubers increase.

In the next section, we discuss the key challenges and opportunities for meeting the future food security of the poor vulnerable groups in SSA.

4 Challenges and opportunities for addressing future food security

4.1 Increasing agricultural productivity

4.1.1 Increasing crop yields
4.1.2 Increasing livestock productivity

4.2 Maintaining low population growth

4.3 Reducing environmental degradation

Food insecurity is closely associated with poverty and so strategies that alleviate poverty will have positive impacts on food security. SSA is the poorest region in the world, with nearly one-half of its population living in extreme poverty and depending heavily on agriculture and natural resources either directly or indirectly for their incomes and food security. Since poor people lack access to alternative sources of livelihood, there is tendency for them to exert more pressure on the little resources that are available to them. Bekele and Holden (1998) show the intensified pressure on natural resources as a vicious cycle in which resource degradation lead to reduced household assets and reduced household assets in turn affect resource degradation. Thus, considering SSA's dismal past performance marked by deteriorating natural resources, stagnant technologies, rising population densities, low public investments and political instability, SSA needs to address some key issues in order to catch up with other developing countries. The major challenges, as the requirements for the desirable outcomes under the alternative scenarios indicate, are increasing agricultural (crop and livestock) productivity, maintaining low population growth and reducing environmental degradation.

4.1 Increasing agricultural productivity

The significant difference in agricultural productivity levels between SSA and other developing and developed countries suggests that there is room for future development of agricultural production in SSA, and it seems that SSA is doing well recently. Though still low, land productivity is rising and labour productivity has increased since 1990, particularly in West Africa (World Bank 2000). Between 1995 and 2000, six countries (Angola, Cape Verde, Equatorial Guinea, Malawi, Mozambique and Rwanda) had annual agricultural growth rates of more than 8% (World Bank 2002), greater than the projected GDP growth rate under the optimistic scenario. In addition, more than 14 countries registered growth rates in excess of 4%. This gives rise to the notion that achieving high growth rates to realise the outcomes under the optimistic scenario in SSA is possible. In general, raising and maintaining high production of agriculture can be done primarily through increases in crop yields and livestock productivity, since the opportunities for expanding crop and livestock areas are very limited, both ecologically and economically (Binswanger and Pingali 1988; Crosson and Anderson 1994).

4.1.1 Increasing crop yields

With a historical (1965–2000) modest growth in crop yields (e.g. 2.5% for cereals, see Figure 8), the entire SSA should reach the 2020 baseline projected yield of 1380 kg/ha. In more recent years (between 1995 and 2000), 10 countries in SSA had average cereal yields in excess of 1380 kg/ha (World Bank 2002). Furthermore, three of those countries (Madagascar, Mauritius and Sao Tome and Principe) had average cereal yields in excess of 1896 kg/ha, the projected cereal yield requirement in 2020 under the optimistic scenario. However, the modest increases in yields are not enough to reach the food security level under the optimistic scenario, requiring an annual growth rate of 4.5% in cereal yields between 1997 and 2020.

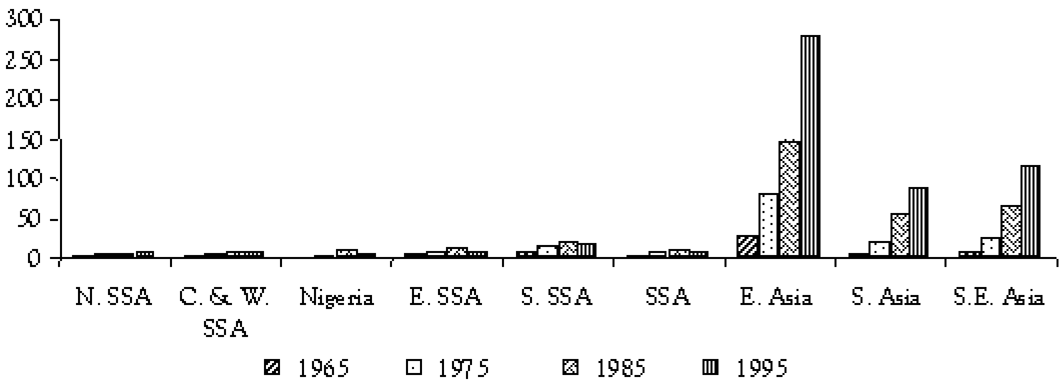
It is clear that problem of soil fertility is the principal constraining factor for raising and sustaining crop yields in SSA (Larson and Frisvold 1996; Sanders and Ahmed 2001), as almost all the soils in SSA show negative nutrient balances, with East and West African soils losing more than 60 kg of NPK per hectare each year (Henao and Baanante 1999). Without sufficient soil nutrients, crop yields cannot increase, be sustained, or respond to improved management practices, improved seed varieties, or other inputs (Larson and Frisvold 1996).

The success of the green revolution in Asia, marked by dramatic increases in crop yields, was fuelled by the adoption of high yielding varieties of rice and wheat and heavy fertilisation on irrigated lands (Spencer 1994). Cereal production rose by 92% using only 4% more land during the three decades beginning in 1969/71. In East Asia, for example, fertiliser consumption rose by more than 850% from 29 to 281 kg/ha of arable land in 1965 and 1995, respectively (Figure 37). In SSA, on the other hand, fertiliser consumption remained very low, rising from a low 3 kg/ha of arable land in 1965 to only 8 kg in 1995 (Figure 37). It is true that fertilisation without sufficient water supply is economically risky, and SSA does not have the irrigation facilities as in Asia where the green revolution was successful,[5] although improved seed and fertiliser technologies have led to steady yield increases in rain-fed agriculture in SSA. Fortunately too, there are numerous soil-water retention technologies (e.g. stone and soil bunds and terraces and tied ridges) that can be utilised with moderate fertilisation in the semi-arid areas. With respect to seed technologies, there are several high-yielding and disease resistant varieties, produced by international (e.g. International Maize and Wheat Improvement Center (CIMMYT), International Institute for Tropical Agriculture (IITA), West Africa Rice Development Association (WARDA) and International Centre for Tropical Agriculture (CIAT)) and national agricultural research institutions that have been widely adopted.

> 5. Spencer (1994) showed what it would cost countries in the humid and sub-humid tropics in SSA to reach the 1990 level of irrigation coverage in China (45.4 million hectares) by 2020. On average, they would need to spend US$ 10.8 billion, or 18% of 1991 GDP annually, which is almost double of the total amount of Overseas Development Assistance (ODA) received in the humid and sub-humid tropics for all sectors each year (Spencer 1994). Spencer (1994) argued that the investments in irrigation and rural access road systems that existed in India at the start of the green revolution are almost beyond the capacity of SSA countries.

Thus, although the irrigation capacity that fuelled the success of the green revolution in Asia may be beyond SSA's reach, significant positive impacts of use of improved seed varieties and fertilisers in many high-rainfall areas or in conjunction with water retention technologies in semi-arid areas show promise of what is possible in high-agricultural potential and semi-arid areas, respectively. See Sanders et al. (1996), Shapiro and Sanders (1998), and Ahmed et al. (2000), for case studies on the success of fertilisation in SSA. Eleni and Haggblade (2001) reviewed several promising individual case studies that show impressive achievements of increasing crop productivity; notably, maize production in Ethiopia and Ghana, bananas in Rwanda and Uganda, cotton in francophone West Africa, vegetables in Kenya (and recently Uganda, Zimbabwe and Zambia) and rice production in central and West Africa.

Given the impressive availability and adoption of seed and water-harvesting technologies, greater fertilisation (organic and inorganic) seems to be the necessary condition for raising crop yields. Although other low-cost fertilisation techniques (e.g. crop rotation, manuring, composting, leguminous crop cover, ploughing in crop residues and fallowing) are useful, many of them (e.g. manuring and ploughing in crop residues) are mainly recycling methods and do not necessarily improve soil fertility and can be very costly when used alone (Larson and Frisvold 1996). In addition, the fallow system, which was widely practised, is disappearing rapidly due to population pressure. In sum, given the high and declining soil nutrient deficiencies, use of improved varieties and low external inputs alone cannot bring about the desired improvement in crop production.



Source: Based on World Development Indicators (World Bank 2002).

Figure 37. *Fertiliser consumption (kg/ha of arable land), 1965–95.*

4.1.2 Increasing livestock productivity

Increasing livestock productivity can have a significant impact to achieving food security and alleviating poverty in SSA, as it is an important asset especially in the rural smallholder household economy (Ehui et al. 1998; Ehui 1999). Increasing livestock productivity, however, will be very challenging. For example, between 1995 and 2000, Sudan and Ethiopia ranked 7th and 8th in the world in terms of cattle population, averaging 34 and 33 million, respectively (FAO 2000). However, they ranked 188th and 184th in terms of beef and veal productivity, averaging 108 and 109 kg/head, respectively. These productivity levels were far below the world average of 198 kg/head. On a positive note, however, there were several other countries (especially in southern Africa) that had productivity levels in excess of 200 kg/head, showing the potential in SSA. Overcoming animal health, feed and genetic constraints, especially in Sudan and Ethiopia, will be very important in raising and maintaining high production levels in SSA as a whole.

Animal health. Farmers in SSA typically lack low-cost, easy-to-use diagnostics, vaccines and control strategies for disease organisms and vectors. Among the parasitic diseases, trypanosomosis, transmitted by tsetse flies, poses an enormous constraint to cattle production in most of the humid and sub-humid zones of SSA. It is estimated that trypanosomosis reduces cattle and milk offtake by up to 30 and 40%, respectively, and reduces the work performance of draft animals by up to 30% (ILRI 1998). Kristjanson et al. (1999) have shown that the potential benefits of trypanosomosis control in terms of meat and milk productivity alone are worth over US$ 100 million per year in Africa. Other important parasitic diseases groups include helminthiasis and tick-borne diseases. Ticks have the capacity to transmit diseases notably theleiriosis (or East Coast fever) in eastern and southern Africa. Infectious diseases such as reinderpest, foot and mouth disease (FMD), contagious bovine pleuropnemonia (CBPP), and *pestes des petits ruminants* (PPR) also pose a major threat. These diseases are epizootic and manifest themselves as epidemics and affect large numbers of cattle.

Efforts at combating animal diseases in SSA show promise. For example, reinderpest, which was 'imported' from Asia in the late nineteenth century and killed an estimated 95% of Africa's cattle, has been controlled across the continent (Mack 1970 and Reader 1997, cited in Eleni and Haggblade 2001). In Ethiopia for example, reinderpest was eradicated in the southern part by 1994 and in the northern part by 1996 (FAO 1998).[6] ILRI has developed an improved ELISA (enzyme-linked immuno-sorbent assay) to diagnose East Coast fever that is currently being used in many countries, including Uganda, Kenya, Tanzania, Zimbabwe, Madagascar, Swaziland and several countries in West Africa (ILRI 1998). As a next step, ILRI is in the process of developing a rapid `pen-side test' for simple and easy detection of infection on farms. Another area that has shown promise in disease control is the research of ILRI in tsetse control in the Ghibe Valley of Ethiopia (ILRI 1998).

6. Tom Randolph brought this reference to reinderpest eradication to our attention.

Biotechnology offers promise for the improved diagnosis and treatment of animal disease, by benefiting from greater resources available to human health research. For example, genomics, which is a new science applicable to humans and livestock that permit sequencing and mapping of the genome (a genetic map of a living organism), takes advantage of the work of the genomes of disease organisms and permits the development of new generations of vaccines, including those that use recombinant antigens to pathological agents (Fitzhugh 1998; Delgado et al. 1999). In this area, ILRI is collaborating with The Institute of Genomics Research (TIGR) to sequence the *Theileria parva* genome in an effort to produce a vaccine for East Coast fever. ILRI is also collaborating with the University of Massachusetts and the Kenya Agriculture Research Institute (KARI) to study the mechanism by which the African buffalo is able to eliminate trypanosomes from its blood and then apply the knowledge to develop cattle that are able to withstand the disease (ILRI 1998).

Feed and feed use. Traditional grazing systems have come under increasing pressure from increasing growth in human population and subsequent competition to use land for other purposes. Generally, a lot of the feed constraint facing livestock production and development in SSA can be relaxed through the use of storage and conservation, high-protein leguminous fodder, treatment of crop residue and addition of mineral nutrients. ILRI and many national agricultural research institutions have developed several feed production and utilisation technologies that offer prospects for alleviating the problem of feed shortage, although the adoption of these technologies, except where they were tested, have so far been low. Fodder bank in sub-humid Nigeria (Elbasha et al. 1999), alley farming in West Africa and Kenya (Jabbar et al. 1996), oat-vetch intercrop in the Ethiopian highlands and napier grass and leguminous tree combination for smallholder dairy in Coastal and Central Kenya (Darnohofer 1997) are examples of some of the technologies that show promise.

Here too, biotechnology offers good prospects for improvements in feed efficiency (Delgado et al. 1999). Numerous compounds have been developed to promote faster growth and improved feed efficiency, such as the use of anabolic steroids in cattle as a growth promotant. Also becoming well recognised is the elevation of natural levels of somatotropins (naturally-occurring protein hormones) in cattle, pigs, poultry and sheep. The identification of suitable traits and their molecular markers can help improve the quality of tropical feeds derived from crops breeders use to develop dual purpose crops with improved grain and protein content for humans and non-ruminants and higher quality crops residues for ruminants. Plant genomics and phytochemistry will tackle anti-nutritional factors, some of which can be poisonous to ruminants. Microbial techniques exist that can help enrich ruminant ecosystems with microbes that can better detoxify anti-nutritional factors to help utilise the vast production of fibrous biomass of low quality feed that is available especially in the sub-humid SSA. Although most of these techniques may not be widely available in SSA, ILRI's work in collaboration with many other Consultative Group on International Agricultural Research (CGIAR) centres and advanced and national agricultural research institutions show promise in enhancing the availability and efficiency of utilisation of feed resources.

Genetic enhancement. The introduction of exotic genes (through artificial insemination, crossbreeding, embryo transfer etc.) has enabled genetic improvement within herds and flocks to be speeded up. Artificial insemination is a well-known reproductive technology that has been in use in developed countries for over one-half a century. It has become a common practice especially in the dairy cattle subsector to cross local breeds in SSA with highly productive varieties from other developing countries and the developed world to achieve more productive herds. The improvement of smallholder dairy production in Coastal and Central Kenya is SSA's success story. It is estimated that households with crossbred dairy cows have monthly incomes of nearly 124 times those households with local cows (ILRI 1998).

Other techniques to enhance genetic improvement include the splitting of embryos to produce multiple copies of genetically identical animals, embryo cloning, *in vitro* fertilisation and sex determination. Recent advances in cloning of embryos could potentially have a large impact on livestock production, particularly of dairy cattle in the developed world. However, this is still an area where a number of complex ethical issues have yet to be resolved (Cunningham 1997). Advances in genetics also offer new means to improve livestock. For example, genetic markers help breeders identify those animals that carry desirable genes without having to wait for a long time before testing them. Genetic improvement has been enhanced even further with the aid of biotechnology, which involves the use of living organisms to produce improvements within animals, such as the various genetic engineering techniques to manipulate genetic material and to transfer genes from one organism to another. In such ways, animal quality may be rapidly upgraded through improvements in genetic make-up and in the rate of reproduction.

4.2 Maintaining low population growth

At 2.6% per year, SSA's population growth is the highest in world. The troubling thing is that, in more recent years (1995–2000), most of the top ten most populous countries (led by Nigeria, Ethiopia and Democratic Republic of Congo) had growth rates in excess of 2.6% (World Bank 2002). Furthermore, nine countries (Angola, Democratic Republic of Congo, Congo Republic, The Gambia, Madagascar, Mauritania, Niger, Rwanda and Swaziland) had average annual population growth rates of 3% or more. Thus, the challenge in reducing and maintaining low population growth is real. However, although current growth rates are high, they have also declined in recent years (World Bank 2002). If the downward trend continues, then there is potential for achieving the 2020 food security projections under the low population scenario. Otherwise, with a population of 640 million in 2000 and projected to reach 959 million by 2020, producing additional food for 319 million (or 50%) more people in just 20 years can be a daunting task!

Nevertheless, it seems that reducing population growth is not an option, as recent evidence about the effects of population growth on agricultural production does not show promise for SSA to meet the food security needs otherwise. The evidence seem to weigh against Boserup's optimistic view that population pressure will lead to intensification of agriculture resulting in higher yields and more production per capita in support of the neo-Malthusian perspective that population increases lead to more environmental degradation and poverty. Most of the literature on SSA (e.g. Barbier 1996; Benin et al. 2001; Pender et al. 2001) suggests that population pressure is more often linked to extensification, land degradation and declining yields than to intensification, land conservation and welfare improvement.

Population growth can have and has had a deleterious effect on agricultural growth, resource management and poverty in SSA. Reduction of arable land per capita has led to reduction in activities such as fallowing, planting trees and investing in conservation structures, and also caused cropping and grazing activities to be shifted to ecologically fragile areas. Without adequate alternative sources of energy, population growth increases the demand for fuelwood, which in turn leads to the destruction of forests. Population increase also contributes to the use of crop residues and dung for fuel rather than using them as sources of organic fertiliser to improve the already poor soils. Shortage of land has its repercussions on livestock stocking rates and pastures. Since most of the land that is fertile is reserved for crop production, grazing of cattle and other livestock is limited to marginal deforested areas, thus increasing overgrazing and degradation and in turn reducing livestock productivity.

It is important to note, however, that population pressure can have positive impacts on land management and productivity. Examples in Kenya and other places show that intensive farming systems can be sustainably managed under conditions of very high population densities (Turner et al. 1993; Tiffen et al. 1994). However, whether productivity and resource-improving intensification occurs depends on the presence of appropriate local technical and institutional innovation, and how rapidly such innovation responds to increasing population.

4.3 Reducing environmental degradation

The natural resource base on which the livelihood of the rural poor in SSA depend is deteriorating at an alarming rate. Land, the most important natural asset, suffers from severe degradation in the form of soil erosion, nutrient depletion and deforestation. Loss of arable land due to soil erosion is a widespread phenomenon in the highland areas of SSA, particularly in the East African highlands. For example, in Ethiopia, soil losses exceeding 200 t/ha per year have been recorded on steep hillsides (Kappel 1996). Nutrient depletion is also widespread. Henao and Baanante (1999) reported that almost all of SSA show negative nutrient balances, with West and East African soils losing more than 60 kg of NPK per hectare each year. Excess removal of forests for fuelwood and timber is also contributing to environmental degradation through increased soil erosion and river siltation, loss of species and biodiversity and emission of carbon dioxide, which contributes to global warming. Within SSA, deforestation is highest in central and West Africa. Between 1980 and 1990, although SSA lost 1.5% of its land area allocated to forests and woodland, central and western Africa lost more than 3.1% (FAO 2000).

The impacts of land degradation on agriculture are numerous. In Ethiopia, for example, it is estimated that 0.1 to 2% of total crop production is lost annually due to soil erosion alone (Kappel 1996). In SSA, the net annual losses of nutrients have been valued at US$ 1.5 billion per year in terms of the cost of nutrients as fertilisers (Henao and Baanante 1999). Although, there exists many methods for combating degradation, traditional methods of controlling soil erosion and restoring soil fertility and vegetative cover are undermined by growing scarcity of land and fuelwood, while modern technologies are inaccessible to the majority of the rural poor.

5 Policies and strategies for future food security

5.1 General policies

- 5.1.1 Improve human resource
- 5.1.2 Improve investment in agricultural research
- 5.1.3 Markets, infrastructure and institutions
- 5.1.4 Natural resources management
- 5.1.5 Macro-economic policies
- 5.1.6 Globalisation

5.2 Sub-regional strategies

- 5.2.1 The humid zone
- 5.2.2 The sub-humid zone
- 5.2.3 The semi-arid zone
- 5.2.4 The arid zone
- 5.2.5 The highlands

Taken together, SSA's dismal performance in the past, gloomy 2020 projections and key challenges and opportunities for addressing food security suggest that it would be unwise for SSA countries to adopt a *business-as-usual* attitude on future food security. Reducing poverty, increasing agricultural productivity, maintaining low population growth and reducing environmental degradation are essential to achieving future food security, and several policies can help to promote this goal.

First we examine a broad range of policy actions including improvement in human resource and agricultural research, competitive market environment, natural resource management, and macro-economic stability that are necessary for success in the entire SSA. Then we examine particular strategies for specific sub-regions, based on the comparative advantage that exist in a particular location and recognising that no *one-size-fit-all* strategy will achieve food security everywhere in the region.

5.1 General policies

5.1.1 Improve human resource

Good nutrition, health and education are important indicators of well-being, which is necessary for active participation in a nation's development process. Thus, policies to improve health and nutrition must deal with poverty-relating diseases such as human immunodeficiency virus/acquired immuno deficiency syndrome (HIV/AIDS),[7] tuberculosis and malaria, and must provide access to safe drinking water and food. Health, water and nutrition education programmes to generate public awareness are also crucial. Increasing school enrolment especially for women is very important, as improving status and education of women have been shown to improve household nutrition and food security.

> 7. AIDS have had a devastating impact on agricultural production in SSA, through its negative impact on life expectancy. In 2000, about 70% of the people estimated to have AIDS worldwide were found in SSA, with 16 countries having

more than 10% of their adult population affected (FAO 2001).

5.1.2 Improve investment in agricultural research

Currently, many donors and stakeholders are concerned that several decades of agricultural research have not had the desired impact on agricultural productivity, poverty and food security, as the projects they have funded had aimed to achieve. Thus, it is important to revisit the research agenda and increase investments in agricultural research that leads to improved technologies to: increase poor farmers' production; provide poor farmers and landless people with greater employment opportunities and higher wages; benefit a wide range of poor people through growth in both rural and urban economies; lower food prices for all consumers; increase physical and economic access to foods that are high in nutrients and crucial for the well-being of the poor, especially women and children; and reduce the vulnerability of the poor to shocks via asset accumulation (Hazell and Haddad 2001). It is also important that agricultural research should not choose technologies for poor farmers, but rather make available a menu of technology options from which they can choose to fit their own needs and resources.

5.1.3 Markets, infrastructure and institutions

Fair, proper-functioning markets and access to both inputs and food at reasonable prices are needed for poor farmers to fully capture the benefits from improved human resources and access to improved technologies. Improved and timely access to credit, productive inputs (especially inorganic fertilisers) and extension, especially to women farmers are crucial. Women's potential contribution to agricultural production have not been adequately nurtured, although evidence shows that if women had access to the same amount of capital and productive inputs as men, the value of their farm output would increase by up to 24% (see Quisumbing et al. 1998 for review of the evidence). Policies (taxes and subsidies) that create distortions in capital markets to favour large enterprises and limit capital to small-scale farmers must be removed.

Increasing investments in rural access roads and irrigation are also critical, as these are among the top investments driving agricultural growth in the 2020 projections. Whether expanding or rehabilitating existing infrastructure will have to be evaluated on a case-by-case basis by individual governments. However, the investments should not be restricted to high agricultural potential areas, as Fan and Hazell (2000) have shown that less favoured areas can give the most growth for an additional unit of investment, and investment in less favoured areas also has more impact on poverty reduction.

5.1.4 Natural resources management

As the opportunities for expanding agricultural area are limited, ecologically and economically, most of the increases in agricultural growth will have to come from increase in crop and livestock yields. Thus, ensuring sustainable increased yields through improved technologies for management of water and land and effective property rights to natural resources is important.

More agricultural research leading to improved technologies and extension to help poor farmers solve problems of soil erosion and nutrient depletion is necessary, in addition to providing better access to credit and fertiliser. Cheap alternative sources of fuel and construction material to reduce deforestation, policies that increase the profitability of maintaining forests (Kaimowitz et al. 1998), and policies to mitigate the negative effects of global warning and climatic change are also needed.

5.1.5 Macro-economic policies

The effectiveness of the above policy actions will depend on macro-economic polices, especially those related to exchange rates and trade. Correcting overvalued exchange rates and removing policies that discriminate against export will be important.

Good governance and integrating the civil society into government will be needed to eliminate conflict, which severely impact household and national food security. Several African countries have experienced significant civil conflict over the past decade, and millions have been killed, maimed, or displaced and deprived of their livelihoods. Conflicts present enormous challenge to rural development, as it takes land out of production, reduces labour force and reduces the incentives to invest in farms and other businesses. It also consumes scarce national resources that could otherwise be spent on health care, education, infrastructure, research and other investments for development. For example, in 1995, SSA spent 2.5% of its GNP on military resources (World Bank 2002). In Angola, however, it was as high as 18%. Although military expenditure in SSA as a whole declined between 1985 and 1995, it rose for many others, including Angola, Botswana, Burundi, Rwanda, Sierra Leone and The Sudan. Conflicts continue in Angola, Democratic Republic of the Congo, Somalia and Sierra Leone. Even the best domestic policies would fail to create a favourable agricultural and economic growth under these conditions.

Although the private sector and market systems should be allowed to operate without distortions, governments should endeavour to provide an enabling environment through decentralisation and providing or improving public goods needed by the poor, including an effective and fair legal system.

5.1.6 Globalisation

The effects (both negative and positive effects on poverty and food security) of globalisation-international trade liberalisation, opening up of economies and free flow of capital, labour, information and technology-are inevitable. Thus, SSA needs to identify those potential effects and adopt policies that will minimise the negative effects and maximise the positive effects of globalisation on the rural poor. Historically both developed and developing countries, including SSA, have maintained protective barriers to agricultural and agro-industrial trade. This has had negative consequence for agricultural development in SSA by constraining opportunities for raising incomes as well as alleviating poverty. However, while in recent years SSA has reduced the barriers to agricultural trade considerably, developed countries' agricultural policy reforms and the last round of the trade negotiations initiated only limited actions to reduce or eliminate barriers to agricultural and agro-industrial trade. For example, Organization for Economic Cooperation and Development (OECD) farmers remain protected by subsidies that are in sum equivalent to Africa's total GDP. This is making it difficult for SSA farmers to compete in their markets, as those adverse trade policies are accelerating the declining trend in world agricultural prices. In addition to the subsidies of the OECD countries, there are non-tariff barriers; and environmental standards are ready to be imposed as another set of non-tariff barriers.

OECD countries need to take a big picture view of trade in which developing countries are potentially huge markets for their industrial and service products. However, that requires that the millions of rural poor people are raised out of poverty and acquire sustained purchasing power. Barriers to agricultural trade in commodities in which SSA has a comparative advantage are protecting relatively small agricultural sectors in OECD countries at the expense of markets for their own major industries. While we concur that domestic policy reforms in SSA need to continue, we believe that the focus has to be on removing the constraints on agricultural trade imposed by developed countries. Specifically, we argue that export subsidies in the developed countries should be outlawed and domestic producer subsidies removed. Access to developed countries markets under tariff quotas must be increased and tariff escalation on processed agricultural products removed. Trade is a 'two-way street' and it is very much in the self-interest of the developed countries to promote fair and freer trade in agriculture.

Protectionism in SSA is not the solution either. SSA countries should continue to reform their domestic policies to be competitive in global markets. To achieve this, as discussed above, they need to eliminate internal biases against agriculture, increase investment in rural infrastructure, health, education and human capital in general. They would also need to promote improved agricultural technology for the smallholder farmers; improve management of land and water resources; improve tenure security; facilitate the vertical integration of small farmers with processors; and improve the organisational abilities of the small farmers.

5.2 Sub-regional strategies

SSA is endowed with diverse agricultural environments, primarily determined by climate, natural resources, and population density. The region is usually divided into five agro-ecological zones (AEZ) (humid, sub-humid, semi-arid, arid and highlands), based on rainfall, temperature and altitude. Table 12 shows the distribution of AEZs by geographical region. The dry areas (semi-arid and arid) account for 54% of the total area and are very prominent in SSA, except in central Africa. Central Africa has the largest share of the humid zone (59%), while the sub-humid zone is spread all over. The highlands, within the semi-arid, humid and sub-humid zones and primarily found in East Africa, cover only 5% of the total area. Identifying the specific and effective policy strategies and investments required for future food security should start by considering the comparative advantage of various livelihood strategies (pathways of development) that exist in different situations and agro-ecological zones. The following discussion draws heavily from Ehui et al. (1995), Pender et al. (1999), Ehui et al. (2000), Pender (2000) and Place (2000).

Table 12. *Agro-ecological zones (AEZs) of sub-Saharan Africa.*

AEZ	Area (%)					
	West	Central	East	Southern	Area of zone (%)	Area of zone (× 10^6 km^2)
Arid	54	1	52	20	36	7.7
Semi-arid	20	7	18	34	18	4
Sub-humid	16	29	16	38	22	4.8
Humid	10	59	2	7	19	4.1
Highlands	0	4	12	1	5	1
Total	100	100	100	100	100	
Total area (× 10^6 km^2)	7.3	5.3	5.8	3.2		21.6

Source: Adapted from Ehui et al. (1995).

5.2.1 The humid zone

The humid agro-ecological zone consists of forests and forest-savannah transition and stretches along the coast of West and central Africa and into the central Congo Basin. Here, most of the farmers who are smallholders grow complex mixtures of food and tree crops. The soils are very acidic and easily degraded without vegetative cover. Soil degradation is the major constraint to food production in this zone. The principal degradation process occurs through leaching and acidification, which leads to toxicities and nutrient imbalances. As a result, the soils often lose fertility after few years of cultivation and require long rest periods.

The potential is greatest for root crops (e.g. cassava and yam) and tree crops (e.g. cocoa and rubber). Thus, improved and disease resistant varieties are needed for crops such as yam, plantain and cocoyam. The International Institute for Tropical Agriculture's (IITA) biological control programme against cassava pests is a success story (Eleni and Haggblade 2001). Given that most of the tree crops produced is exported for foreign exchange, priority for investment is in improving the road network and marketing facilities. Due to declining world prices for key agricultural commodities, diversification into high-value commodities and reduction in production and marketing costs will be important. Although trypanosomosis is a major factor limiting livestock production, there is a high potential for meat production in making available disease resistant breeds, such as the N'Dama, and improving the animal health delivery system. Feed constraint can be alleviated through increased digestibility of crop residue biomass (which is plentiful in this zone) that will not otherwise be used by livestock. With increased population densities, crop-livestock interactions are increasing (e.g. Bunaji dairy around Ibadan (Fitzhugh, personal communication)) and creating opportunities for more manure availability and soil fertility enhancement. Complementary soil fertility amendment methods with inorganic fertilisers need to be encouraged through extension and education.

5.2.2 The sub-humid zone

This zone consists of savannah type vegetation and, although, trypanosomosis is a major problem here, crop-livestock systems are more common because of heavier soils that make operation of the plow more profitable. It offers greatest potential for increased production of meat and milk. Thus, livestock production should be promoted through the introduction and promotion of resistant breeds, improving health infrastructure etc. In areas with good market access (e.g. areas around Kaduna in Nigeria or Bamako in Mali), where fattening and milk production will be important, extension, education and credit in adopting livestock feed technologies such as planting of forage legumes, which help to restore soil fertility within a short fallow period and also increasing subsequent crop production, will be important.

Although high yielding varieties exist for most of the crops (e.g. maize, sorghum, millet, soybean and cowpeas) cultivated in the zone, they are not widely adopted, especially in areas with poor market access and low precipitation. This is because the high costs of complementary purchased inputs that are required for such high yielding varieties erode their profitability, especially since the removal of fertiliser subsidies. Therefore, to realise the potential of the zone, modern, stress-resistant varieties that respond well to small amounts of external inputs are needed.

5.2.3 The semi-arid zone

The soils in this agro-ecological zone are poor and deficient in nitrogen and phosphorus, and the high temperatures accelerate degradation of plant organic matter and reduce the water-holding capacity of the soil. Because trypanosomosis and other livestock diseases are less prevalent here, livestock production will be important, as diseases continue to constrain livestock production in the humid and sub-humid zones. Given the poor soils and limited precipitation, crop production is likely undertaken for subsistence only, with very little resources devoted to livestock production, except in areas where there is good access to markets. Therefore, to enhance the potential of this zone, especially areas with better market access, investment priority will be in extension, education and credit in livestock fattening programmes, milk production and improved marketing and health facilities. Facilitating the intensification process will be the use of groundnut and cottonseed cakes, which are rich in protein, and by-products of groundnut processing into oil, and cottonseed processing into lint. In areas that are more remote from cities and markets, small ruminants, as opposed to cattle, will be more important, since small ruminants are more capable of being trekked over long distances.

5.2.4 The arid zone

This zone covers the largest portion of the region (36%). Receiving less than 500 mm of rain annually, nomadic and transhumant pastoral systems based on communal grazing are the dominant farming systems. The arid zone has the lowest capacity to supply food of plant origin, though it is well suited for grazing. Hence ruminant livestock production remains the only practical means of transforming pasture and browse forage into food and income. Population pressure combined with erratic rainfall lead to uncontrolled grazing around water points, range degradation and increasing property rights conflicts. Thus, drought-resistant modern varieties and extension and education in soil and water conservation methods will be important. Migration to more fertile areas will be the only sustainable livelihood strategy for many people. Thus, training in intensive agriculture and non-farm activities will also be important. For those remaining pastoralists, improvement in property rights to pastures and water resources will be crucial.

5.2.5 The highlands

The highland areas, consisting of areas of 1200 metres above sea level (masl) in Burundi, Ethiopia, Kenya, Rwanda, Tanzania and Uganda, have a bi-modal rainfall and mean daily temperatures less than 20°C. The favourable climate, moderate disease and pest problems make the highlands attractive to people and livestock. Indeed, the highlands have the highest density of people and livestock in SSA. Livestock production will maintain a comparative advantage, as diseases continue to constrain livestock production in other parts of SSA. As a result of high densities, farm sizes are small, with much of the farming activities taking place on steeply sloping land. The highlands are also marked by rapidly disappearing forests, high levels of erosion, cultivation into marginal lands, declining use of fallow, limited investment in soil and water conservation measures and limited use of fertilisers (modern and organic). However, as rainfall averages 1000 mm per year and there are a variety of soils with good stability, most of the highland areas are considered to be of good agricultural potential.

In areas close to urban or foreign markets and having high agricultural potential, the potential is greatest for profitable production of high-value perishable commodities, such as horticultural crops and dairy products. To realise this potential, investment in infrastructure and development of input and credit markets will be required. The dairy development in Coastal and Central Kenya is a major success story. In areas with high agricultural potential, but very far from markets, there is potential for production of high-value non-perishable crops, such as coffee as well as livestock. However, with high cost of transportation being a limiting factor in use of external inputs, other soil fertility improving techniques (e.g. agroforestry and composting) will be important in increasing crop yields. For example, banana farmers in Uganda are achieving higher yields with composting. Technical assistance to improve crop-livestock interactions will also be important.

In areas with low agricultural potential, but with high market access (such as northern Ethiopia and western Uganda), crop production will not have a comparative advantage without irrigation. Thus, investment in irrigation (where suitable) and water conservation techniques should be given high priority. Facilitating non-farm rural development through education, vocational training, electrification and telecommunications will also be important. In areas with low agricultural potential and far from markets, livestock (especially small ruminants) and high-value forest products (including resin and honey) may have a comparative advantage. In addition, seasonal migration will be important, and so investment in human capital may have the greatest social returns.

6 Conclusions

About 23% (180 million) of world's food insecure people live in SSA. This paper provides an outlook on food security in SSA to 2020. The paper also discusses the challenges and opportunities for meeting the food security needs of the poor vulnerable groups and then examines policy strategies for achieving future food security in SSA.

Over the past two decades (1975–95), per capita consumption of cereals stagnated in most sub-regions of SSA. For the entire SSA, per capita consumption of cereals increased only slightly from 109 kg in 1975 to 114 kg in 1995, with central and western SSA recording the lowest per capita consumption. With respect to livestock products, although the average per capita consumption of meat, milk and eggs in the world increased significantly, those in SSA either stagnated or declined or increased only slightly. Per capita consumption of meat, milk and eggs in SSA in 1995 were only 9.5, 23.9 and 1.4 kg, respectively, which were about 27, 31 and 20% of the respective world averages. The 2020 projections show that although per capita consumption of food crops and livestock products will increase only modestly, total consumption will double between 1997 and 2020 as a result of rapid population growth. In terms of food utilisation, total daily calories supply will increase by 10% over the 1997 level to reach 2442 calories per capita in 2020, while the number of malnourished children under the age of five will increase by 20% (or 6.7 million children), with most of the increases taking place in northern SSA.

Looking at alternative scenarios that mimic the past dismal performance of SSA, where GDP growth is low and agricultural productivity and investments declining, show that total daily calorie supply will fall below the 1997 level to 2162 per capita, and the number of malnourished children will increase to 48.6 million in 2020. To overcome these and achieve a more optimistic growth path similar to that projected for other developing countries, where total daily calorie supply is 3232 per capita and the number of malnourished children is 22 million, SSA needs to tackle major challenges to reducing poverty, increasing agricultural (crop and livestock) productivity, maintaining low population growth and reducing environmental degradation.

The policy actions that can help address these challenges and achieve future food security include: improving human resource in the area of health and education, especially for women; increasing investments in agricultural research that leads to improved technologies to increase production, provide greater employment opportunities and higher wages, lower food prices, and reduce the vulnerability of the poor to shocks via asset accumulation; improving markets, infrastructure and institutions so that poor farmers can fully capture the benefits from improved human resources and access to improved technologies; and adopting policies that will ensure sustainability of increased yields through improved technologies for management of water and land and effective property rights to natural resources. Specifically, policy distortions (e.g. subsidised credit) that favour large-scale enterprises need to be removed. Institutions that can link small-scale producers with large-scale processors especially for perishable products need to be created. Policies to reduce physical and transaction costs so as to expand market participation of smallholders need to be put in place. In addition, policies related to exchange rates and trade must be corrected. Strategies to internalise environmental costs should be developed in order to prevent pervasive financial incentives to large-scale enterprises. Where health and environmental problems exist, regulatory mechanisms need to be developed. For the very poor, nutritional programmes to increase food consumption need to be in place. Good governance and integrating the civil society in decision making and sharing of national benefits to avoid civil conflicts are also important. Providing an effective and fair legal system is also crucial.

Since globalisation—international trade liberalisation, opening up of economies and free flow of capital, labour, information and technology—is inevitable, SSA needs to position itself and adopt policies that will minimise the negative effects and maximise the positive effects of globalisation on the rural poor and food security. The domestic policies mentioned above will help SSA countries respond better to the effect of globalisation. But the international community should help eliminate the constraints on agricultural trade imposed by the developed countries. Export subsidies should be outlawed and domestic producer subsidies reduced. Access to developed countries markets under tariff quotas must be increased and tariff escalation on processed agricultural products removed. Unlike in OECD where agriculture is a relatively small sector, in SSA, agriculture presents the biggest opportunities for poverty alleviation. In SSA, agriculture accounts for 20% of the region's GNP, employs 67% of the total labour force, is the main source of livelihood of the region's poor and is a significant export sector in most of the sub-regions (47% of export in East Africa, 14% in southern Africa and 10% in West Africa) (Dixon et al. 2001).

Given that no *one-size-fit-all* strategy will achieve food security in entire SSA, due to the diverse situations and complex factors that influence agricultural and rural development, identifying specific and effective policy strategies and investments for future food security should start by considering the comparative advantage of various livelihood strategies (pathways of development) that exist in different situations and locations. Within the humid zone, since the greatest potential is for root crops and tree crops, providing modern varieties of those crops that are disease resistant and respond well to small amounts of purchased inputs will be needed. In addition, investments in roads and markets should have a high priority. The humid zone also offers high potential for meat production through making available disease resistant breeds, such as the N'Dama, and improving health delivery systems and improving digestibility of the plentiful biomass in the zone. In the sub-humid zone, because crop-livestock systems are more common, introducing disease resistant animal breeds and improving health infrastructure are key. In addition, providing modern crop varieties that are stress-resistant and respond well to small amounts of external inputs will be needed. Since livestock production is important in the semi-arid zone, policy strategies should focus on extension, education and credit in livestock fattening programmes, milk production and improved marketing and health facilities. In the arid zone, the emphasis should be on providing drought-resistant crop varieties and improving property rights to pastures and water resources.

In the eastern African highlands, in areas close to urban or foreign markets and having high agricultural potential, there is great potential for profitable production of high-value perishable commodities, such as horticultural crops and dairy products. To realise this potential, investment in infrastructure and development of input and credit markets will be required. In areas with high agricultural potential, but very far from markets and where high cost of transportation limits the use of external inputs, other soil fertility improving techniques (e.g. agroforestry and composting) will be important in increasing crop yields. In areas with low agricultural potential, but high market access (such as northern Ethiopia and western Uganda), crop production will not have a comparative advantage without irrigation. Thus, investment in irrigation (where suitable) and water conservation techniques should be given high priority. In areas with low agricultural potential and far from markets, livestock and high-value forest products may have a comparative advantage. As seasonal migration may also be important, investment in human capital (e.g. education and vocational training) will be necessary.

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Appendix Sub-Saharan Africa sub-regions, countries and commodities

SSA sub-regions and countries[1]

Central and western SSA

Benin, Cameroon, Central African Republic, Comoros Island, Democratic Republic of Congo, Congo Republic, Côte d'Ivoire, Gabon, The Gambia, Ghana, Guinea, Guinea Bissau, Liberia, Sao Tome and Principe, Senegal, Sierra Leone, and Togo

Eastern SSA

Burundi, Kenya, Rwanda, Tanzania and Uganda

Nigeria

Northern SSA

Burkina Faso, Chad, Djibouti, Eritrea, Ethiopia, Mali, Mauritania, Niger, Somalia and The Sudan

Southern SSA

Angola, Botswana, Lesotho, Madagascar, Malawi, Mauritius, Mozambique, Namibia, Reunion, Swaziland, Zambia and Zimbabwe

Commodities

Cereals

Barley, maize, millet, oats, rice, rye, sorghum and wheat

Roots and tubers

Potatoes, sweet potatoes, yams, cassava and other roots, tubers and rhizomes

Meat

Beef and buffalo meat

Pig meat

Poultry meat

Sheep and goat meat

Milk is raw milk

Eggs are from hens

1. Note that although more than 180 countries, grouped into separate regions and sub-regions, and many commodities are included in the IMAPCT model, only SSA and those commodities discussed in this paper are listed here. For a complete list of regions and countries and commodities, see Rosegrant et al. (2001).