

The Food Security Assessment model used in this report was developed at ERS for use in projecting food consumption and access, and food gaps (previously called food needs) in 67 low-income countries through 2011. The reference to food includes grains, root crops, and a category called “other,” which includes all other commodities consumed, thus covering 100 percent of food consumption. All of these commodities are expressed in grain equivalent.

The food security of a country is evaluated based on the gap between projected domestic food consumption (produced domestically plus imported commercially minus nonfood use) and a consumption requirement. Although food aid is expected to be available during the projection period, it is not included in the projection of food consumption. It should be noted that while projection results will provide a baseline for the food security situation of a country, they depend on assumptions and specifications of the model. Since the model is based on historical data, it implicitly assumes that the historical trend in key variables will continue in the future.

Food gaps are projected using two consumption criteria:

1) *Status quo target*, where the objective is to maintain average per capita consumption of the recent past. The most recent 3-year average (1998-2000) is used for the per capita consumption target in order to eliminate short-term fluctuations.

2) *Nutrition-based target*, where the objective is to maintain the daily caloric intake standards recommended by the UN’s Food and Agriculture Organization (FAO). The caloric requirements (based on total share of grains, root crops, and “other”) used in this assessment are those necessary to sustain life with minimum food-gathering activities. They are comparable to the activity level for a refugee—they do not allow for play, work, or any activity other than food gathering.

The status quo measure embodies a “safety-net” criterion by providing food consumption stability at recently achieved levels. The nutrition-based target assists in comparisons of relative well-being. Comparing the two consumption measures either for countries or regions provides an indicator of the need depending on whether

the objectives are to achieve consumption stability and/or to meet a nutritional standard. Large nutrition-based needs relative to status quo needs, for example, mean additional food must be provided if improved nutrition levels are the main objective. In cases where nutrition-based requirements are below status quo consumption needs, food availability could decline without risking nutritional adequacy, on average. Both methods, however, fail to address inequalities of food distribution within a country.

Structural Framework for Projecting Food Consumption in the Aggregate and by Income Group

Projection of Food Availability—The simulation framework used for projecting aggregate food availability is based on partial equilibrium recursive models of 67 lower income countries. The country models are synthetic, meaning that the parameters that are used are either cross country estimates or are estimated by other studies. Each country model includes three commodity groups, grains, root crops, and “other.” The production side of the grain and root crops are divided into yield and area response. Crop area is a function of 1-year lag return (real price times yield), while yield responds to input use. Commercial imports are assumed to be a function of domestic price, world commodity price, and foreign exchange availability. Foreign exchange availability is a key determinant of commercial food imports and is the sum of the value of export earnings and net flow of credit. Foreign exchange availability is assumed to be equal to foreign exchange use, meaning that foreign exchange reserve is assumed constant during the projection period. Countries are assumed to be price takers in the international market, meaning that world prices are exogenous in the model. However, producer prices are linked to the international market. The projections of consumption for the “other” commodities is simply based on a trend that follows the projected growth in supply of the food crops (grains plus root crops). Although this is a very simplistic approach, it represents an improvement from the previous assessments where the contribution to the diet of commodities such as meat and dairy products was overlooked. The plan is to enhance this aspect of the model in the future.

For the grains and root crops (*c*) commodity group, food consumption (*FC*) is defined as domestic supply (*DS*) minus nonfood use (*NF*). *n* is country index and *t* is time index.

$$FC_{cnt} = DS_{cnt} - NF_{cnt} \quad (1)$$

Nonfood use is the sum of seed use (*SD*), feed use (*FD*), exports (*EX*), and other uses (*OU*).

$$NF_{cnt} = SD_{cnt} + FD_{cnt} + EX_{cnt} + OU_{cnt} \quad (2)$$

Domestic supply of a commodity group is the sum of domestic production (*PR*) plus commercial imports (*CI*) and changes in stocks (*CSTK*).

$$DS_{cnt} = PR_{cnt} + CI_{cnt} + CSTK_{cnt} \quad (3)$$

Production is generally determined by the area and yield response functions:

$$PR_{cnt} = AR_{cnt} * YL_{cnt} \quad (4)$$

$$YL_{cnt} = f(LB_{cnt}, FR_{cnt}, K_{cnt}, T_{cnt}) \quad (5)$$

$$RPY_{cnt} = YL_{cnt} * DP_{cnt} \quad (6)$$

$$RNPY_{cnt} = NYL_{cnt} * NDP_{cnt} \quad (7)$$

$$AR_{cnt} = f(AR_{cnt-1}, RPY_{cnt-1}, RNPY_{cnt-1}, Z_{cnt}) \quad (8)$$

where *AR* is area, *YL* is yield, *LB* is rural labor, *FR* is fertilizer use, *K* is the indicator of capital use, *T* is the indicator of technology change, *DP* is real domestic price, *RPY* is yield times real price, *NDP* is real domestic substitute price, *NYL* is yield of substitute commodity, *RNPY* is yield of substitute commodity times substitute price, and *Z* is exogenous policies.

The commercial import demand function is defined as:

$$CI_{cnt} = f(WPR_{cnt}, NWPR_{cnt}, FEX_{cnt}, PR_{cnt}, M_{cnt}) \quad (9)$$

where *WPR* is real world food price, *NWPR* is real world substitute price, *FEX* is real foreign exchange availability, and *M* is import restriction policies.

The real domestic price is defined as:

$$DP_{cnt} = f(DP_{cnt-1}, DS_{cnt}, NDS_{cnt}, GD_{cnt}, EXR_{cnt}) \quad (10)$$

where *NDS* is supply of substitute commodity, *GD* is real income, and *EXR* is real exchange rate.

Projections of food consumption by income group—Inadequate economic access is the most important cause of chronic undernutrition among

developing countries and is related to the level of income. Estimates of food gaps at the aggregate or national level fail to take into account the distribution of food consumption among different income groups. Lack of consumption distribution data for the countries is the key factor preventing the estimation of food consumption by income group. An attempt was made to fill this information gap by using an indirect method of projecting calorie consumption by different income groups based on income distribution data.¹ It should be noted that this approach ignores the consumption substitution of different food groups by income class. The procedure uses the concept of the income/consumption relationship and allocates the total projected amount of available food among different income groups in each country (income distributions are assumed constant during the projection period).

Assuming a declining consumption and income relationship (semi log functional form):

$$C = a + b \ln Y \quad (11)$$

$$C = C_o/P \quad (12)$$

$$P = P_1 + \dots + P_i \quad (13)$$

$$Y = Y_o/P \quad (14)$$

$$i = 1 \text{ to } 5$$

where *C* and *Y* are known average per capita food consumption (all commodities in grain equivalent) and per capita income (all quintiles), *C_o* is total food consumption, *P* is the total population, *i* is income quintile, *a* is the intercept, *b* is the consumption income propensity, and *b/C* is consumption income elasticity (point estimate elasticity is calculated for individual countries). To estimate per capita consumption by income group, the parameter *b* was estimated based on cross-country (67 low-income countries) data for per capita calorie consumption and income. The parameter *a* is estimated for each country based on the known data for average per capita calorie consumption and per capita income.

Historical Data

Historical supply and use data for 1980-2000 for most variables are from the USDA database. Data for grain production in 2001 for most countries are based on a USDA database as of October 2001. Food aid data are

¹ The method is similar to that used by Shlomo Reutlinger and Marcelo Selowsky in "Malnutrition and Poverty," World Bank, 1978.

from FAO, and financial data are from the International Monetary Fund and World Bank. Historical nonfood-use data, including seed, waste, processing use, and other use, are estimated from the FAO *Food Balance* series. The base year data used for projections are the average for 1998-2000, except export earnings that are 1997-99.

Endogenous variables:

Production, area, yield, commercial import, domestic producer price, and food consumption.

Exogenous variables:

Population—data are medium UN population projections as of 1998.

World prices—data are USDA/baseline projections. Stocks-USDA data, assumed constant during the projection period.

Seed use—USDA data, projections are based on area projections using constant base seed/area ratio.

Food exports—USDA data, projections are either based on the population growth rate or extrapolation of historical trends.

Inputs—fertilizer and capital projections are, in general, an extrapolation of historical growth data from FAO.

Agricultural labor—projections are based on UN population projections, accounting for urbanization growth.

Food aid—historical data from FAO, *no food aid* assumed during the projection period.

Gross Domestic Product—World Bank data.

Merchandise and service imports and exports—World Bank data.

Net foreign credit—World Bank data, assumed constant during the projection period.

Value of exports—projections are based on World Bank (*Global Economic Prospects and the Developing Countries*, various issues), IMF (*World Economic Outlook*, various issues), or an extrapolation of historical growth.

Export deflator or terms of trade—World Bank (*Commodity Markets—Projection of Inflation Indices for Developed Countries*).

Income—projected based on World Bank report (*Global Economic Prospects and the Developing Countries*, various issues) or extrapolation of historical growth.

Income distribution—World Bank data. Income distributions are assumed constant during the projection period.

(Shahla Shapouri)

Appendix table 2a--List of countries and their food gaps in 2001

	2001 food gaps				2001 food gaps		
	Status quo	Nutrition	Distribution		Status quo	Nutrition	Distribution
	1,000 tons				1,000 tons		
Angola	248	280	483	Algeria	0	0	83
Benin	69	0	0	Egypt	0	0	0
Burkina Faso	120	0	137	Morocco	0	0	0
Burundi	24	395	424	Tunisia	0	0	0
Cameroon	50	0	49	North Africa	0	0	83
Cape Verde	60	9	12				
Central African Rep.	11	26	159	Afghanistan	1,880	3,030	3,150
Chad	97	37	205	Bangladesh	0	0	115
Congo, Dem. Rep.	223	1,824	2,135	India	0	0	6,177
Côte d'Ivoire	0	0	0	Indonesia	0	0	0
Eritrea	229	420	438	Korea, Dem. Rep.	1,670	848	959
Ethiopia	1,750	3,949	4,369	Nepal	221	0	63
Gambia	13	0	0	Pakistan	0	0	0
Ghana	75	0	70	Philippines	0	0	0
Guinea	0	0	27	Sri Lanka	0	0	0
Guinea-Bissau	10	0	7	Vietnam	0	0	0
Kenya	0	792	1,151	Asia	3,772	3,878	10,464
Lesotho	35	32	81				
Liberia	190	135	158	Bolivia	0	18	149
Madagascar	0	117	370	Colombia	0	0	45
Malawi	0	0	0	Dominican Rep.	0	0	72
Mali	0	107	285	Ecuador	0	0	99
Mauritania	72	0	0	El Salvador	0	0	211
Mozambique	24	548	773	Guatemala	165	162	327
Niger	373	0	146	Haiti	287	437	498
Nigeria	0	0	0	Honduras	0	0	0
Rwanda	483	310	338	Jamaica	135	205	255
Senegal	0	0	5	Nicaragua	0	0	185
Sierra Leone	124	239	354	Peru	0	0	102
Somalia	167	860	916	Latin America and the Caribbean	586	822	1,944
Sudan	1,362	936	1,133				
Swaziland	7	0	7	Armenia	0	187	63
Tanzania	72	962	1,199	Azerbaijan	0	0	0
Togo	29	0	31	Georgia	0	0	0
Uganda	312	0	42	Kyrgyzstan	0	0	0
Zambia	0	78	290	Tajikistan	299	495	350
Zimbabwe	0	859	1,018	New Independent States	299	682	414
Sub-Saharan Africa	6,227	12,914	16,813				
				Total	10,883	18,296	29,718

Appendix table 2b--List of countries and their food gaps in 2011

	2011 food gaps				2011 food gaps		
	SQ	Nutrition	Distribution		SQ	Nutrition	Distribution
	1,000 tons				1,000 tons		
Angola	653	695	874	Algeria	0	0	358
Benin	24	0	0	Egypt	0	0	0
Burkina Faso	0	0	12	Morocco	0	0	0
Burundi	125	595	630	Tunisia	0	0	1
Cameroon	0	0	25	North Africa	0	0	359
Cape Verde	83	20	23	Afghanistan	1,763	3,428	3,650
Central African Rep.	67	85	226	Bangladesh	0	0	158
Chad	0	0	52	India	0	0	655
Congo, Dem. Rep.	1,512	3,664	4,044	Indonesia	0	0	0
Côte d'Ivoire	0	0	0	Korea, Dem. Rep.	1,207	288	540
Eritrea	272	514	539	Nepal	543	0	149
Ethiopia	0	1,586	2,697	Pakistan	0	0	0
Gambia	30	0	1	Philippines	0	0	0
Ghana	0	0	60	Sri Lanka	0	0	0
Guinea	28	0	47	Vietnam	0	0	0
Guinea-Bissau	0	0	1	Asia	3,513	3,716	5,152
Kenya	0	143	780	Bolivia	0	0	53
Lesotho	48	44	102	Colombia	0	0	0
Liberia	461	382	408	Dominican Rep.	0	0	0
Madagascar	296	461	703	Ecuador	0	0	0
Malawi	0	0	0	El Salvador	0	0	70
Mali	0	0	259	Guatemala	376	373	511
Mauritania	339	65	97	Haiti	77	267	366
Mozambique	0	0	266	Honduras	0	0	0
Niger	581	0	222	Jamaica	109	200	277
Nigeria	0	0	0	Nicaragua	0	0	56
Rwanda	648	435	468	Peru	0	0	0
Senegal	255	0	102	Latin America and			
Sierra Leone	389	532	642	the Caribbean	562	839	1,333
Somalia	375	1,345	1,417	Armenia	0	0	63
Sudan	0	0	113	Azerbaijan	0	0	0
Swaziland	0	0	4	Georgia	0	0	0
Tanzania	0	386	903	Kyrgyzstan	0	0	0
Togo	12	0	32	Tajikistan	78	305	350
Uganda	580	0	83	New Independent States	78	305	414
Zambia	92	380	559				
Zimbabwe	0	0	172				
Sub-Saharan Africa	6,870	11,332	16,563				
				Total	11,023	16,193	23,821

Appendix table 3--Country indicators

Region and country	Population 2001	Population growth rate	Grain production		Root	Projected annual growth in supply	Macroeconomic indicators			Export earnings growth 1998	Official development	External debt
			Growth 1980-2000	Coefficient of variation 1980-2000	production growth 1980-2000		Per capita GNP 1999	Per capita GNP growth 1999	GDP growth 1999		assistance as a share of GNP 1998	(present value) as a share of GNP 1998
	1,000		Percent				U.S. dollars			Percent		
North Africa:												
Algeria	32,171	2.2	-1.0	47.9	4.0	1.4	1,550	3.6	3.3	3.5	0.9	66.0
Egypt	69,707	1.8	5.0	20.8	2.9	1.1	1,290	4.5	6.0	-7.7	2.3	29.0
Morocco	28,827	1.7	0.2	48.2	4.6	1.2	1,240	5.3	-0.7	3.3	1.5	54.0
Tunisia	9,715	1.3	2.5	45.4	4.9	1.4	2,060	4.1	6.2	3.7	0.8	56.0
Central Africa:												
Cameroon	15,481	2.6	2.0	13.8	3.4	2.8	610	3.8	4.4	4.7	5.0	98.0
Central African Rep.	3,681	1.8	1.5	14.3	0.1	1.3	300	2.6	3.4	0.6	11.6	55.0
Congo, Dem. Rep.	53,120	2.8	3.4	9.9	1.3	1.8	110	0.7	3.0	14.3	2.0	196.0
West Africa:												
Benin	6,260	2.7	4.9	14.4	6.1	2.5	380	1.9	5.0	-1.0	9.2	46.0
Burkina Faso	12,266	2.8	5.2	26.7	-5.2	3.4	240	3.8	5.8	10.5	15.5	32.0
Cape Verde	438	2.3	7.1	56.3	0.7	0.9	1,200	2.2	8.0	-3.9	--	--
Chad	7,851	2.6	4.5	20.1	0.9	3.4	230	5.5	-0.7	12.2	10.0	38.0
Côte d'Ivoire	15,077	2.0	2.6	15.2	2.2	2.2	700	3.9	2.8	0.9	7.6	122.0
Gambia	1,342	2.8	2.1	18.8	0.0	2.4	340	2.0	6.4	5.5	--	--
Ghana	20,766	2.7	6.6	33.0	8.3	2.7	390	1.9	4.4	14.4	9.6	55.0
Guinea	7,560	1.7	3.5	20.3	3.3	2.2	530	1.5	3.3	12.8	9.8	69.0
Guinea-Bissau	1,239	2.2	4.3	19.6	3.3	2.8	160	-30.4	7.8	-35.8	--	--
Liberia	3,325	5.4	-4.3	41.1	-0.3	1.0	--	--	--	--	--	--
Mali	11,517	2.8	4.5	11.9	1.7	2.7	250	1.3	5.5	1.3	13.5	84.0
Mauritania	2,743	2.7	8.8	29.6	-0.2	0.8	410	1.5	4.1	8.7	17.8	148.0
Niger	11,068	3.1	3.0	21.3	-2.8	1.9	200	4.8	-0.6	8.7	14.4	55.0
Nigeria	114,092	2.3	5.6	25.8	9.2	2.0	300	-1.5	1.0	-8.3	0.5	74.0
Senegal	9,728	2.6	1.2	19.5	1.2	1.6	520	3.8	5.1	5.2	10.8	58.0
Sierra Leone	4,977	2.5	-2.4	17.0	5.6	-0.1	140	-2.9	-8.1	--	16.2	126.0
Togo	4,748	2.6	4.5	26.9	2.6	2.5	330	-3.5	2.1	-0.3	8.6	68.0
East Africa:												
Burundi	6,852	2.3	-2.6	17.8	1.5	1.9	140	2.6	-1.0	-8.6	8.8	72.0
Eritrea	3,966	3.0	1.1	53.9	0.1	1.2	200	-6.7	0.8	-33.5	19.7	11.0
Ethiopia	64,063	2.4	4.0	21.7	2.2	3.4	100	-4.2	6.2	-9.4	10.0	135.0
Kenya	30,603	1.7	0.1	15.0	2.7	2.0	350	0.3	1.3	-5.8	4.2	45.0
Rwanda	8,063	4.3	-2.7	15.6	-1.6	1.6	230	7.1	6.1	-0.6	17.3	34.0
Somalia	10,506	4.0	-3.6	38.1	2.5	2.4	--	--	--	--	--	--
Sudan	30,113	2.1	2.9	37.3	-3.4	2.3	290	2.7	5.2	--	--	--
Tanzania	34,283	2.3	1.6	16.0	-0.2	2.6	220	3.8	4.7	-10.0	12.5	71.0
Uganda	22,464	3.1	1.9	14.9	1.4	2.8	310	2.8	7.4	-14.9	7.0	35.0

See footnotes at end of table.

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Appendix table 3--Country indicators--Continued

Region and country	Population 2001	Population growth rate	Grain production		Root	Projected annual growth in supply	Per capita GNP 1999	Macroeconomic indicators			Export earnings growth 1998	Official development assistance	External debt (present value)
			Growth 1980-2000	Coefficient of variation 1980-2000	production growth 1980-2000			Per capita GNP 1999	GDP growth 1999	as a share of GNP 1998		as a share of GNP 1998	
	1,000		Percent				U.S. dollars	Percent					
Southern Africa:													
Angola	13,291	3.2	1.8	28.7	5.1	1.8	380	16.3	2.7	-20.5	8.1	279.0	
Lesotho	2,196	2.0	0.5	27.6	9.0	1.6	570	-5.3	2.5	15.8	5.7	42.0	
Madagascar	16,391	2.8	1.1	6.4	1.6	2.2	260	1.7	4.7	1.1	13.5	89.0	
Malawi	11,197	2.5	2.3	26.9	7.7	2.1	210	-1.0	4.0	3.8	24.4	77.0	
Mozambique	20,065	2.0	6.4	55.6	1.8	2.9	210	9.7	7.3	6.5	28.2	74.0	
Swaziland	1,037	2.8	1.6	25.6	-1.1	2.9	1,400	-1.3	2.0	3.0			
Zambia	9,359	2.1	0.0	29.3	6.0	2.2	330	-4.1	2.4	-7.5	11.4	181.0	
Zimbabwe	11,797	1.1	-0.8	31.0	5.2	2.8	620	-1.4	0.1	25.2	4.7	69.0	
Asia:													
Afghanistan	23,787	4.7	-2.1	13.0	-0.7	1.3	--	--	--	--	--	--	
Bangladesh	131,394	1.7	2.4	12.8	0.8	1.7	350	4.2	4.9	14.3	2.7	22.0	
India	1,029,033	1.5	2.7	12.4	3.2	1.7	440	4.3	6.5	4.2	0.4	20.0	
Indonesia	214,889	1.3	1.9	4.1	1.2	1.7	640	-18.0	0.3	11.2	1.5	169.0	
Korea, Dem. Rep.	25,853	1.4	-2.9	22.0	2.7	0.0	--	--	--	--	0.0	43.0	
Nepal	24,483	2.3	3.0	12.1	6.8	1.6	210	0.3	3.9	-10.0	8.3	31.0	
Pakistan	160,605	2.6	2.7	9.7	6.5	2.3	470	0.5	4.0	3.7	1.6	41.0	
Philippines	77,479	2.0	2.0	9.2	0.5	2.1	1,050	-2.1	3.2	-10.4	0.9	66.0	
Sri Lanka	19,018	1.0	0.9	9.7	-5.0	0.9	810	3.3	4.3	1.0	3.2	41.0	
Vietnam	80,946	1.4	5.2	23.0	-2.0	1.7	350	4.3	4.8	--	4.3	76.0	
Latin America and the Caribbean:													
Bolivia	8,517	2.3	2.2	17.2	1.0	2.9	1,010	2.7	0.6	2.7	7.5	59.0	
Colombia	43,074	1.8	-1.1	12.1	1.4	2.9	2,470	-2.4	-4.3	8.8	0.2	32.0	
Dominican Republic	8,624	1.5	-1.2	11.6	1.6	2.9	1,770	4.9	8.3	4.4	0.8	28.0	
Ecuador	12,880	1.8	3.6	25.4	0.9	2.7	1,520	2.2	-7.3	-2.5	0.9	75.0	
El Salvador	6,398	1.9	1.9	9.7	8.1	3.5	1,850	1.1	3.4	1.8	1.5	27.0	
Guatemala	11,687	2.7	0.7	7.3	2.3	3.7	1,640	2.8	3.6	6.0	1.2	23.0	
Haiti	8,359	1.7	0.3	15.2	0.1	0.6	410	1.1	2.2	21.8	10.5	16.0	
Honduras	6,656	2.6	1.7	16.4	3.8	2.4	740	1.1	-1.9	1.8	6.3	64.0	
Jamaica	2,605	0.9	-3.3	51.1	2.4	3.3	1,740	0.1	-0.4	-3.2	0.3	61.0	
Nicaragua	5,215	2.8	1.6	15.0	3.0	1.9	370	3.3	7.0	-6.4	28.1	262.0	
Peru	26,093	1.7	3.2	15.1	2.8	3.6	2,440	-3.3	1.4	3.3	0.8	55.0	
New Independent States:													
Armenia	3,521	0.0	-0.2	17.0	-0.2	1.8	460	3.1	3.3	-0.1	7.1	29.0	
Azerbaijan	7,781	0.6	0.0	15.3	15.1	1.2	480	8.9	7.4	-7.8	2.2	13.0	
Georgia	4,947	-0.4	-0.4	22.5	9.3	1.4	970	2.5	3.3	3.5	4.6	36.0	
Kyrgyzstan	4,734	0.7	-0.7	17.6	17.9	1.7	380	2.8	3.7	-3.5	60.5	3.1	
Tajikistan	6,269	1.3	4.5	31.1	6.4	1.3	370	13.3	3.7	--	--	--	

-- = data unavailable or not applicable due to inconsistent data set.

Source: Population=UN World Population Prospects, 1998; Macroeconomic indicators=World Bank.