

Appendix 1—Food Security Model: Definition and Methodology

The Food Security Assessment model used in this report was developed at the USDA-ERS for use in projecting food consumption and access, and food gaps (previously called food needs) in 67 low-income countries through 2009. This year, North Korea was for the first time included in the analysis. 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.

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 the countries, 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 (1996-98) 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 minimum 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 commodity group grains and root crops (c), 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 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:

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

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:

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

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 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 data¹. 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):

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

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

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

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

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

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

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 of *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 1980-98 for most variables are from a USDA database. Data for grain production in 1999 for most countries are based on a USDA database as of October 1999. Food aid data are from the UN's Food and Agriculture Organization (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 1996-98, except export earnings that are 1995-97.

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—is 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 2a--List of Countries and Their Food Gaps in 1999

	1999 food gaps				1999 food gaps		
	Status quo	Nutrition	Distribution		Status quo	Nutrition	Distribution
	---Million tons---				---Million tons---		
Cameroon	6	0	138	Algeria	348	0	88
Centr. Afr. Rep.	12	71	128	Egypt	0	0	0
Congo (Zaire)	136	1,838	2,136	Morocco	3,012	0	483
Burundi	22	401	451	Tunisia	0	0	0
Eritrea	80	307	321	North Africa	3,360	0	571
Ethiopia	901	4,023	4,285				
Kenya	209	249	1,016	Afghanistan	248	681	1,045
Rwanda	527	326	351	Bangladesh	410	773	1,757
Somalia	192	882	932	India	0	0	5,416
Sudan	67	0	54	Indonesia	1,841	0	0
Tanzania	351	536	872	Korea, North	391	771	931
Uganda	178	0	93	Nepal	100	0	71
Angola	105	366	516	Pakistan	505	0	0
Lesotho	49	44	88	Philippines	0	0	0
Madagascar	75	162	371	Sri Lanka	0	0	0
Malawi	0	0	0	Vietnam	0	0	0
Mozambique	144	656	1,086	Asia	3,495	2,225	9,221
Swaziland	16	0	3				
Zambia	30	538	635	Bolivia	118	244	337
Zimbabwe	454	420	651	Colombia	0	0	252
Benin	0	0	0	Dominican Rep.	0	0	39
Burkina Faso	0	0	147	Ecuador	0	0	217
Cape Verde	54	3	8	El Salvador	0	0	40
Chad	0	141	251	Guatemala	73	0	285
Côte d'Ivoire	187	0	7	Haiti	75	285	419
Gambia	0	0	1	Honduras	0	102	235
Ghana	135	0	71	Jamaica	0	0	0
Guinea	0	0	45	Nicaragua	50	0	98
Guinea-Bissau	4	0	4	Peru	0	0	291
Liberia	173	95	139	Latin Am.	316	632	2,214
Mali	0	0	31				
Mauritania	0	0	1	Armenia	150	96	121
Niger	5	0	81	Azerbaijan	287	290	346
Nigeria	365	0	0	Georgia	79	84	131
Senegal	0	0	61	Kyrgyzstan	255	0	4
Sierra Leone	138	151	202	Tajikistan	103	475	514
Togo	50	14	95	NIS	874	945	1,116
SSA	4,664	11,222	15,268	Total	12,709	15,023	28,390

Appendix 2b--List of Countries and Their Food Gaps in 2009

	2009 food gaps				2009 food gaps		
	SQ	Nutrition	Distribution		SQ	Nutrition	Distribution
	---Million tons---				---Million tons---		
Cameroon	329	106	350	Algeria	1,105	0	143
Centr. Afr. Rep.	85	156	203	Egypt	118	0	0
Congo (Zaire)	1,254	3,533	3,899	Morocco	0	0	0
Burundi	107	587	646	Tunisia	0	0	0
Eritrea	193	485	501	North Afr.	1,223	0	143
Ethiopia	0	3,270	3,651				
Kenya	0	0	813	Afghanistan	1,999	2,635	2,887
Rwanda	848	588	618	Bangladesh	834	1,263	2,310
Somalia	589	1,567	1,626	India	0	0	1,378
Sudan	178	0	83	Indonesia	0	0	0
Tanzania	501	733	1,141	Korea, North	836	1,263	1,396
Uganda	586	0	265	Nepal	543	0	187
Angola	650	1,001	1,136	Pakistan	1,390	0	0
Lesotho	47	42	98	Philippines	402	0	12
Madagascar	521	635	791	Sri Lanka	181	0	36
Malawi	316	481	534	Vietnam	0	0	0
Mozambique	59	663	1,208	Asia	6,185	5,160	8,207
Swaziland	4	0	1				
Zambia	265	897	1,005	Bolivia	30	186	326
Zimbabwe	0	0	293	Colombia	0	0	63
Benin	136	0	0	Dominican Rep.	0	0	0
Burkina Faso	150	160	375	Ecuador	0	0	180
Cape Verde	75	11	15	El Salvador	24	0	25
Chad	0	209	344	Guatemala	409	196	509
Côte d'Ivoire	0	0	0	Haiti	317	565	671
Gambia	0	0	0	Honduras	93	254	352
Ghana	291	0	129	Jamaica	0	0	0
Guinea	0	0	73	Nicaragua	297	190	285
Guinea-Bissau	23	0	8	Peru	80	0	579
Liberia	524	409	446	Latin Am.	1,249	1,391	2,990
Mali	148	0	145				
Mauritania	7	0	9	Armenia	0	0	6
Niger	533	311	445	Azerbaijan	0	0	9
Nigeria	0	0	0	Georgia	0	0	0
Senegal	0	0	152	Kyrgyzstan	0	0	0
Sierra Leone	315	331	377	Tajikistan	0	415	447
Togo	37	0	107	NIS	0	415	462
SSA	8,769	16,175	21,487				
				Total	17,427	23,141	33,288

Appendix 3--Country Indicators

Region and country	Population 1998	Population growth rate	Grain production		Root production growth 1981-96	Projected annual growth in supply	Per capita GNP 1996	Macroeconomic indicators			Months of import coverage in reserves 1996	Debt service ratio 1996
			Growth 1981-96	Coefficient of variation 1981-95				Per capita GNP growth 1996	GDP growth 1996	Export earnings growth 1996		
	1,000		-----Percent-----				U.S. dollars	----- Percent-----				
North Africa												
Algeria	30,481	2.2	-1.3	43.9	5.6	2.1	1,520	1.8	3.8	9.6	--	9.7
Egypt	66,009	1.9	5.0	5.3	2.4	1.5	1,080	3.5	5.0	8.4	10.8	3.4
Morocco	31,004	2.0	3.9	51.1	5.0	2.4	1,290	10.4	11.5	6.3	3.9	8.9
Tunisia	9,326	1.6	2.8	63.2	5.1	2.6	1,930	-0.4	7.0	0.5	--	8.0
Central Africa												
Cameroon	14,762	3.0	0.5	8.0	1.6	1.6	610	4.5	5.0	6.3	0.0	6.3
Central African Rep.	3,399	1.8	1.8	16.7	-1.4	0.8	310	-5.0	-2.8	-1.4	--	1.2
Zaire	48,371	3.1	3.5	8.3	2.4	1.8	130	-0.1	1.3	29.9	--	0.8
West Africa												
Benin	6,101	3.4	4.4	10.6	5.4	2.5	350	3.2	5.8	20.0	--	2.0
Burkina Faso	11,295	2.6	6.6	13.7	-5.9	2.3	230	3.3	6.1	1.8	--	1.9
Cape Verde	476	2.9	11.8	89.1	-0.9	0.9	1,010	-24.6	4.7	25.0	--	1.4
Chad	5,961	2.2	3.8	18.8	1.2	2.4	160	0.5	2.8	7.5	--	2.7
Côte d'Ivoire	16,320	3.3	3.9	7.4	2.4	2.4	660	4.6	5.9	24.1	1.5	13.8
Gambia	1,085	3.1	3.8	16.9	0.0	3.0	--	--	--	--	4.0	--
Ghana	19,439	3.0	3.2	22.2	6.7	3.6	360	2.3	5.0	19.8	4.4	7.6
Guinea	7,036	2.4	3.5	9.8	1.2	2.1	560	1.8	4.5	-3.2	1.0	3.0
Guinea-Bissau	1,206	2.4	9.3	16.1	2.6	1.8	250	3.7	5.2	8.9	--	4.2
Liberia	3,392	3.3	-6.0	40.7	9.2	1.0	--	--	--	--	--	--
Mali	10,185	2.8	6.5	13.9	-0.1	2.9	240	1.2	4.0	6.4	--	4.5
Mauritania	2,478	3.0	12.9	47.1	-0.6	1.7	470	1.8	4.5	7.4	--	11.6
Niger	10,205	3.0	2.2	16.0	1.7	2.1	200	-0.1	3.3	--	--	2.9
Nigeria	111,081	3.0	0.2	18.2	10.3	2.6	240	1.9	3.5	15.9	4.1	8.1
Senegal	9,894	3.2	2.2	20.1	3.3	1.7	570	3.2	5.6	4.8	--	5.4
Sierra Leone	5,143	2.7	-2.6	11.3	4.6	0.9	200	7.6	4.8	6.5	--	6.4
Togo	4,897	3.4	4.8	16.1	0.2	2.3	300	4.3	6.2	-0.9	--	4.0
East Africa												
Burundi	6,669	2.1	-1.1	19.6	1.9	1.7	170	-11.1	-8.8	-49.3	--	2.7
Eritrea	4,270	3.1	1.0	--	1.3	1.3	--	--	--	--	--	--
Ethiopia	60,310	2.7	2.0	11.0	1.3	3.0	100	7.2	10.3	4.9	5.1	5.8
Kenya	30,975	2.6	1.1	14.8	2.3	2.0	320	3.1	4.3	13.3	2.5	9.4
Rwanda	9,280	2.5	-2.5	14.6	-1.6	2.2	190	7.8	11.4	40.5	4.9	1.4
Somalia	8,596	3.3	-1.8	37.1	0.5	1.1	--	--	--	--	--	--
Sudan	33,060	3.3	2.9	39.0	-5.0	1.8	--	--	--	--	0.9	--
Tanzania	30,481	2.2	1.4	12.6	0.3	2.2	170	--	--	--	2.3	4.5
Uganda	21,042	2.1	2.6	6.0	1.3	2.6	300	6.2	9.1	19.2	3.8	2.5

See note at end of table.

Appendix 3--Country Indicators (continued)

Region and country	Population 1998	Population growth rate	Grain production		Root production growth 1981-96	Projected annual growth in supply	Per capita GNP 1996	Macroeconomic indicators			Months of import coverage in reserves 1996	Debt service ratio 1996
			Growth 1981-96	Coefficient of variation 1981-95				Per capita GNP 1996	GDP growth 1996	Export earnings growth 1996		
	1,000		-----Percent-----				U.S. dollars	----- Percent-----			Number	Percent
Southern Africa												
Angola	10,913	2.7	-1.9	19.3	4.5	1.7	270	-1.7	7.0	12.8	--	20.1
Lesotho	2,088	2.4	1.2	30.2	9.2	1.7	660	6.7	11.9	9.0	--	2.9
Madagascar	15,243	3.2	1.4	3.1	2.1	1.6	250	0.5	2.0	9.7	2.5	1.9
Malawi	11,018	2.4	3.0	21.7	0.2	2.3	180	13.0	14.5	1.5	--	4.1
Mozambique	19,728	2.9	1.4	24.7	0.4	2.4	80	5.0	6.1	14.5	--	11.3
Swaziland	1,066	3.3	2.5	30.8	0.0	2.4	1,210	-0.3	2.5	3.3	2.4	3.2
Zambia	10,178	2.4	2.0	31.7	4.6	1.7	360	3.4	4.9	-3.5	--	9.8
Zimbabwe	12,084	2.2	1.1	37.4	5.4	1.1	610	5.8	7.3	12.2	--	9.2
Asia												
Afghanistan	26,519	6.1	-3.6	7.9	-0.5	1.2	--	--	--	--	--	--
Bangladesh	137,240	2.3	2.2	4.0	0.3	1.6	260	3.8	5.3	10.6	2.9	2.2
India	985,921	1.7	2.9	5.2	2.9	1.7	380	5.1	7.5	7.5	5.1	3.6
Indonesia	213,133	1.5	2.0	3.3	1.7	1.2	1,080	5.8	7.6	6.3	--	9.9
Nepal	23,202	2.5	3.2	8.3	7.2	1.6	210	1.8	5.3	0.5	4.5	1.9
Pakistan	141,030	2.6	2.2	4.8	6.0	2.3	480	0.3	4.6	2.0	0.9	5.1
Philippines	78,229	2.2	2.5	4.5	0.4	2.1	1,160	4.5	5.7	20.3	--	6.6
Sri Lanka	18,969	1.1	0.9	9.1	-4.6	1.0	740	0.5	3.8	3.9	3.7	3.1
Vietnam	78,147	1.6	0.9	5.0	-1.9	1.7	290	--	9.3	--	--	1.5
Latin America												
Bolivia	8,435	2.2	3.1	15.2	0.6	2.0	830	2.6	--	--	7.8	6.5
Colombia	38,014	1.6	-3.5	6.2	0.0	2.5	2,140	-0.5	2.0	4.4	5.6	6.6
Dominican Republic	8,366	1.7	0.1	9.7	2.5	2.6	1,600	5.7	7.4	13.3	0.8	3.5
Ecuador	11,915	1.9	0.7		0.0	2.0	1,500	1.2	1.9	3.6	4.1	7.4
El Salvador	6,226	1.9	2.7	10.4	9.0	2.7	1,700	0.0	2.5	7.4	--	3.0
Guatemala	11,841	2.4	2.0	4.3	1.7	1.0	1,470	8.6	3.0	6.1	3.0	2.3
Haiti	6,807	1.4	-1.8	8.3	0.4	1.8	310	0.0	2.0	20.7	1.7	1.0
Honduras	5,737	2.6	3.1	12.0	4.3	2.4	660	-0.3	3.1	15.0	--	14.1
Jamaica	2,609	0.7	-6.4	60.2	3.2	1.7	1,600	-1.9	-1.7	1.0	--	15.9
Nicaragua	4,537	2.5	1.7	16.1	4.2	2.7	380	4.2	4.7	37.9	1.5	13.2
Peru	25,393	1.7	2.0	13.9	0.8	2.0	2,420	0.0	2.8	10.1	10.9	4.9
New Independent States												
Armenia	3,469	0.1	2.0	53.6	0.8	2.1	630	7.4	--	--	2.2	3.0
Azerbaijan	7,793	0.7	2.0	52.7	0.8	2.1	480	-1.3	1.2	--	--	0.3
Georgia	5,145	-0.6	2.0	52.6	0.8	1.8	850	12.7	--	--	--	0.3
Kyrgystan	4,566	0.6	2.0	51.8	0.8	1.5	550	4.1	5.6	--	60.5	3.1
Tajikistan	6,124	1.8	2.0	51.2	0.8	1.9	340	-8.4	-4.4	--	--	0.0

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

Source: Population=Census data.