

## Appendix 1—Food Security Model: Definition and Methodology

The Food Security Assessment model used in this report was developed by USDA's Economic Research Service for use in projecting food consumption and access and food gaps (previously called food needs) in low-income countries through 2014. The reference to food is divided into three groups: 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 minus nonfood use) and a consumption requirement. Like last year, we are using total food aid data (cereal and non-cereal food commodities). These data are provided by the World Food Program (WFP). All food aid commodities were converted into grain equivalent based on calorie content to allow aggregation. For example: grain has roughly 3.5 calories per gram and tubers have about 1 calorie per gram. One ton of tubers is therefore equivalent to 0.29 ton of grain (1 divided by 3.5), one ton of vegetable oil (8 calories per gram) is equivalent to 2.29 tons of grain (8 divided by 3.5).

It should be noted that while projection results will provide a baseline for the food security situation of the countries, results 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 (2001-2003) is used for the per capita consumption target to eliminate short-term fluctuations.

2) *Nutrition-based target*, where the objective is to maintain the minimum daily caloric intake standards of about 2,100 calories per capita per day—depending on the region—recommended by the U.N.'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 or work.

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 addi-

tional 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 70 lower income countries.<sup>1</sup> 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 lagged 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. Food aid received by countries is assumed constant at the base level during the projection period. 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 projection 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 by commodities to the diet, such as meat and dairy products, was not considered. 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*), changes in stocks (*CSTK*), and food aid (*FA*).

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

<sup>1</sup> These countries are low- and lower middle income countries as classified by the World Bank.

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 an 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:

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

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:

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

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 income level. 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 study 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 data.<sup>2</sup> 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).

<sup>2</sup> The method is similar to that used by Shlomo Reutlinger and Marcelo Selowsky in "Malnutrition and Poverty," World Bank, 1978.

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 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 (70 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 1980-2003 for most variables are from a USDA database. Data for grain production in 2004 for most countries are based on a USDA database as of October 2004. Food aid data are from the U.N.'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 uses, are estimated from the FAO Food Balance series. The base year data used for projections are the average for 2001-2003, except for export earnings, which are 2000-2002.

### ***Endogenous variables:***

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

### ***Exogenous variables:***

*Population*—data are medium U.N. population projections as of 2000.

*World price*—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*—1988-2003 data from World Food Program (WFP).

*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.

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