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Introduction to Food Security Analysis

The World Food Summit in 1996 established a target of reducing by the year 2015 the number of undernourished, food insecure people in the world to one-half the level that existed in the early 1990's.

Within the United States, an Interagency Working Group (IWG) was created after the World Food Summit to prepare an Action Plan in support of this target. Such an Action Plan required an analysis of the prevalence and causes of world undernutrition and food insecurity. It also required systematic projections about whether and how food insecurity and undernutrition would be affected by various interventions.

To complete this analysis in 1998 USAID's Global Bureau's Office of Economic Growth and Agriculture Development (EGAD), contracted with the Association for International Resources and Development (AIRD) to complete such an assessment. (APAP III Research Report 1039; USAID Contract No. LAG-C-oo-93-00052-00).

Reproduced below is a portion of AIRD's food security analysis for this report. While this section does not provide a step-by-step methododology or "how-to" guide to country-level food security analysis, it does describe clearly the most critical questions examined during their analysis, key data elements and some results of such an analysis.

Most important it summarizes how the several "interventions" might affect food insecurity. These "interventions" include the following:

- Political Instability
- Democratization
- Economic Openness
- Food Tariff Reductions
- Rural Roads
- Agriculture Research

- Targeted Food Aid
- Household Interventions
- Access to Safe Water

FOOD SECURITY MODEL DESCRIPTION

The Food Security model seeks to evaluate for a set of specific interventions the impact of each intervention on the projected population of undernourished in the year 2015. The analysis is conducted separately for 14 countries or sub-regions of the world. These are: China, Indonesia, the Rest of East/South East Asia, Bangladesh, India, Pakistan, the Rest of South Asia, Nigeria, Ethiopia, the Rest of War Tom Africa, Least Developed Africa, the Rest of Developing Africa, Latin America and the Rest of the World. The quantification of variables related to undernutrition for each region is derived from a subsample of 98 countries of the world. (Appendix Table A.7 provides a list of the countries grouped into each region).

Measuring the number of undernourished

The assessment of the total number of undernourished relies on anthropometnic estimates of the proportion of children 0-5 years who are underweight in each country. These data have been assembled by the WHO global database on child growth and are reported the Sixth World Food Survey (1996).

Projections of the numbers undernourished are estimated based on IFPRI's global food model entitled IMPACT (International Model for Policy Analysis of Agnicultural Commodities and Trade). The IFPRI model, reported in Rosegrant, Leach, and Gerpacio Guly 1998), relies on the following variables to project child malnutrition.

- **per capita kilocalorie availability,**
- **percent of social expenditures as a share of total expenditures,**
- **percent of females with secondary education,**
- **percent of households with access to clean water, and**
- **a dummy variable for South Asia to estimate child undernutrition.**

The projections to the year 2015 rely on changes in each of these variables. The projection of changes in kilocalorie availability is evaluated directly by IFPRI's IWACT model. IMPACT includes 18 commodities (all major cereals, soybeans, roots and tubers, meats and dairy products) and covers 37 countries and regions. Each country or region is defined by a series of supply and demand equations and is linked to the rest of the world through trade. Crop prices and projected rates of productivity growth determine food

supply growth in each country. Food demand is a function of food prices, *income and population growth. Details of the basic methodology of the model are described in Rosegrant et. al. (1995). For countries not included in the IFPRI model, we have relied on projections by the FAO of food availability to the year 2010.

' The text of this report discusses the relative merits of this measure.]

Projected changes to the year 2015 for other variables of the IFPRI /RvIPACT child undernutrition model where unavailable. Therefore, assumptions were made reflecting a continuation of trends in each variable between 1970 and 1990. These trends are reported below, as is the assumed cumulative change by the year 2015.

Table 1: Assumed increases in underlying variables between 1995 and 2015

Female secondar,v	Food availability (DES) enrollment Rate %	Access to safe Water (%)
East and Southeast Asia	18%	41%
South Asia	15%	82%
Sub-Saharan Africa	27%	49%
Latin America and Caribbean	5%	19%
Rest of World	15%	25%

The extrapolator to the total number of undernourished in the population from the projected number of children undernourished assumes that the percent of undernourished in the larger population is proportionate to the percent of children under 5 who are undernourished. However, the proportion used is not a one-to-one ratio, but rather assumes that the rate of undernutrition of people over 5 years old is 50% of the child undernutrition rate. This proportion is used for two reasons. First a comparison of the percentage of underweight adults to the percentage of underweight children in a small sample of surveys for which both are available suggests that the mean ratio of adult to child rates of undernutrition is roughly 50%. This empirical evidence is admittedly very weak both because the sample of countries is small, (6 surveys) and because the range in the ratio sought is quite large between countries. Secondly, using this measure, the current total number of

total undernourished in 1995 (915 Billion) is roughly equivalent to the FAO number of total undernourished in 1990-92 (840 billion). This similarity is expedient, even if not entirely accurate, because it allow us to argue that, using this measure, we are addressing the same magnitude of problem in 1995 that the FAO identified in the World Food Summit of 1996. As the discussion in the text points out, however, the regional distribution of these numbers is substantially different, with South Asia showing much greater numbers of undernourished, while sub-Saharan Africa shows fewer undernourished.

Assessing the impacts of interventions

For each intervention evaluated, the model analyzes the direct impact of a change in the proposed intervention on undernutrition. This involves several simplifying assumptions.

First the analysis of each intervention is conducted independently of all other interventions. This implies that interventions are not complementary and do not have either synergistic or contradictory effects on undernutrition. Thus, for example, improvements in rural roads are not assumed to improve the efficacy of agricultural research. This assumption also ignores any preconditions that may exist with regard to some interventions.

For example, open trade policy is likely to be an important factor in determining the extent of income effects generated by sectoral investments such as agricultural research or investment in rural infrastructure. It should be noted, however, that while the model's construction ignores these obvious relationships, they are addressed explicitly in the scenario analyses, which put together the packages of interventions that are expected to be most effective in specific regions or countries.

A second set of assumptions concerns the temporal element of the model. In each case, the analysis seeks to estimate the percent change in the number of undernourished in the target year (2015). The model does not develop growth paths of each impact over the interval between the introduction of the intervention and the target year. Thus, while the intervention may occur progressively over the 15-year interval between the introduction of the intervention in 2000 and the target date of 2015, the only measure of

impact is in 2015. Moreover, the ultimate impact is calculated as a reduction in the percent of the projected number of undernourished people in that year in each region or country evaluated. This implies that the intervention has no impact on demographic projections of population to that date which might change the base level of undernutrition in the target year.

A related assumption is that regardless of when in this interval each intervention occurs, it is assumed to have lasting effects on the number of undernourished through the target date and into the future. As such, each intervention's effects are assumed to be 46 permanent" over the horizon of the analysis.

To establish links to undernutrition, all impacts (except the Political Stability and Targeted Food Aid interventions) are traced through various pathways to three underlying variables, which Smith and Haddad (1997) have found to be most influential in explaining child undernutrition. These underlying factors are - food availability, female secondary education, and access to safe water. The interventions operate per-capita income which in turn affects each of these variables. This pathway - from intervention, to income, to food availability, female secondary education, and access to safe water, and finally to child undernutrition - is the mechanism through which all other national and sectoral level effects are assumed to operate. Household and intra-household interventions on the other hand, impact one or several of these directly. Table 2 below provides the multipliers and elasticities for each of these relationships.

Table 2: Parameters Used In Relating Underlying Variables To Child Undernutrition

	Impact of Income on Underlying variables		Impact of Underlying variables Child Undernutrition %	
Underlying variables	Parameter	Elasticity	Parameter	Elasticity
Access to Safe Water	0.000092	0.343	-0.085	-0.164
Female Sec. Ed	0.000083	0.528	-0.168	-0.202
Food Avail. (DES)	0.1414	0.124	-0.00081	-0.0732

Source: Smith and Hadad, (1998, draft), updated as explained in note (B)

a) These parameters are expressed by Smith and Haddad as percentage points. In the Model, these are expressed as fractions and therefore each parameter is reduced by a factor of 100. b) These parameters have been updated from the original text by Smith using the latest data from the 1998 version of the World Development Indicators. Estimates in the draft paper used 1997 data.

The impact of each intervention on the broader population of undernourished is extrapolated from the impact on child undernutrition. As with the relationship in the general population, no literature could be found which examined this relationship for any of the interventions used in the model. The model therefore makes the following assumptions. First, it assumes a one to one relationship between the impact of each on older children (between the ages of 5 and 15 years old) and the measured impact for children through 4 years old. This relationship is assumed, because children affected by interventions at the beginning of the intervention period will be 15 years old by the end. Interventions are therefore assumed to have had the same impact on each age cohort.

With respect to the adult population, on the other hand, interventions affecting children are assumed to have four times as great a percentage effect on adults. This assumption derives from the different character of undernutrition in the adult population. A large component of underweight adults are underweight because of stunting at an early age (nearly all stunting occurs before the age of five). Stunting in adults is not remediable. What is remediable, however, is wasting in the adult population, which is the ratio of weight to height. The facility of correcting for this problem is assumed to be reflected by the ratio of wasted to underweight persons 'in the population. Lacking specific measures for adults, the ratio from child malnutrition surveys is used. This ratio is consistently dose to four for most developing countries of the world. 2

Lastly, the cost of each intervention is assessed based upon unit cost data for quantifiable 'interventions.

National Level Interventions

At the national level, four (4) policy-based interventions have been examined. These address political stability, democratization, and openness and trade tariff reform. In addition to the direct and/or indirect effects that each has on undernutrition7 all are also considered to be necessary components of a policy environment conducive to interventions which are more closely linked to the undernourished. **Some interventions, particularly at the household and intra-household level may be feasible, but interventions at the sectoral level are not likely to be worthwhile 'in the absence of these reforms.**

Before turning to the details of each intervention it should be noted that because each intervention at this level is of a policy nature, the costs difficult to quantify. An approach to this problem is proposed for all interventions at the end of this section rather than for each intervention individually.

[Cf. Sixth World Food Survey Table 8.]

Intervention 1: Political Stability

Logic: The well-known direct negative effects of civil war and strife on physical security are assumed to reduce people's ability to access food. In addition, food production and therefore availability is disrupted. Furthermore, during periods of war the general level of public services is curtailed both because of difficulty in accessing and the general shortages of funds to provide them. Finally, income reductions and asset losses due to war reduce people's entitlement to food.

Data and Assumption: The intervention analysis examines the impact of establishing peace before 2015 in each region or country where war and civil strife have been present in the last ten years. To assess this effect, a cross-country OLS regression was used to evaluate child undernutrition levels between 1990-92 as a function of the country having been a war torn country in the last ten years, as well as other underlying variables associated with child undernutrition. The results consistently show a highly significant increase of about 8 percentage points in the level of undernutrition of children, holding other underlying variables constant (region, female education, access to safe water, female status), due to the presence of war. Regression results on the impact of war on

undernutrition in children are presented in appendix Table A.6. The War variables for each of the focus countries and regions in the analysis is presented 'in Appendix Table A. 1.

Obviously, the costs of achieving peace in these countries are difficult to assess. However, the scale of interventions are not necessarily high if proactive measures to avert conflict can be taken. Budgets sufficient to engage conflicting parties in sustained dialogue are included. This dialogue would rely on conflict avoidance and resolution techniques. These efforts would necessarily be coupled with a heightened and concentrated effort by the world community to apply sustained pressure on opponents to use these procedures to resolve their differences. The process of estimating costs *involved *in this process are examined at the end of this section.

Intervention 2: Democratization

Logic: The effect of democratization on reducing undernutrition is traced through its impact on creating a more equitable Location of public resources to components of the population where the undernourished are concentrated. The model relies on measurements of this effect by Smith and Haddad. Specifically, they measure a direct link between the degree of democratization and the Location of public resources to provide access to safe drinking water. Safe drinking water, in turn, directly affects the health of individuals and therefore their capacity to absorb nutrients. This link is discussed further under Intervention 8 below.

Data and Assumptions. Measurement of the current status of democratization uses the arithmetic average of two measures of rights that are typically attributed to democracies. These measures are scores of civil and political liberties. The assumption in the analysis is that this index I improves over the interval berween1995 and 2005 by 30 % of the gap between the current level and the optimum, level, which is seven. This assumption reflects a rate of change of roughly twice the historical rate of improvement it. the index over the past twenty years.

This change is related to access to safe water using Smith and Haddad's finding that a 1-point gain in the democracy index increases water access by 3.51 %. Access to safe

water is then related to child undernutrition through the multiplier reported in Table 2.

This approach is likely to underestimate the impact of democratization on undernutrition to the extent that democratization also improves access and raises the quality of other public services to the undernourished as well. These may include such things as health care Services, education, transport and telecommunications infrastructure.

Intervention 3: Economic Openness

Logic: The impact of open policies on the volume of trade and on economic growth is now well established. Openness has both a direct impact on GDP growth and indirect effects through its effect on trade and investment, each of which also impacts income growth. These combined effects are assumed to have an annual compounding effect on per capita income growth for the period 'in which openness is sustained. Income accountability, in turn is assumed to have impacts on the three underlying variables affecting child undernutrition - food availability, female secondary education, and access to water - as ,indicated 'in Table 2 above.

Data and assumptions: The definition of economic openness uses a variable developed by Sachs and Warner (1995). This variable classifies countries as open according, to cut-off levels of the black market exchange rate premium, the influence of export marketing boards, the level of coverage of quotas on imports of intermediate and capital goods, and the absence of a socialist government. A country is considered open when all four conditions are met in a given year; otherwise the variable equals zero.

The direct relationship of trade openness to income growth and the indirect relationship to income via its impact on trade has been measured by Stryker and Pandolfi. These combined effects all estimated by Sachs and Warner to add on the order of 2% to growth rates for developing countries. This parameter is therefore assumed in the analysis.

The openness status of countries or regions in 1995 is assumed to be the base condition from which changes can be obtained. In the analysis, it is assumed that open status can be achieved by the year 2005 for countries that are not

open, and that this status can be maintained through the target year. For re ional groupings covering more than one country, the openness parameter represents a population-weighted average of the openness parameter.

As noted above, the impact of these effects on income growth are compounded annually for successive years of openness (15 years). Appendix Table A.1 presents the levels of openness, their impact on 'income growth and the compounded effect on per capita income levels at the end of the projection period for each country and sub-region.

Intervention 4: Food Tariff Reductions

In addition to these income effects, a related effect of the impact of trade openness is traced through the effect of reduced trade restrictions on the cost of food. This applies in particular to policy reforms that remove quantitative restrictions and lower tariff barriers to food imports. The justification of this impact Is that for countries which currently tax or otherwise restrict food staple imports, a reduction in the level of protection of these imports will reduce the domestic price of food staples by roughly the same percent. The percentage price change for staples is translated into a change in food caloric availability Using a long-run price elasticity of demand for calories. The impact of food caloric availability on the number of undernourished is then traced through its relationship to child undernutrition using the equations provided by Smith and Haddad (see above), and then to total numbers of undernourished.

With regards to the impact of price changes induced by changes in trade policy, current levels of Import protection were estimated from producer prices taken from the World Bank Development Indicators and global prices in 1993. Both world prices and local producer prices where adjusted to a common urban wholesale point, inclusive of intermediate processing margins. Rates of protection were also adjusted by deflating by the ratio of the nominal to the real, economic exchange rates. These show that, with the exception of South Asia, all country/sub-regions had net nominal protection coefficients substantially in excess of One. The assumption in the analysis is that these are brought down to a target level of 1.0 by the year 2015.

To evaluate the impact on caloric availability, a long run price elasticity of demand for calories of -0.2 was used for all countries and sub-regions. This estimate denotes from comparisons of estimates used in a variety of sources.

[Footnote: 3C.F review of literature by Sebastian Edwards, 1993, "Openness, Trade Liberalization and Growth in Developing Countries, " Journal of Econo7nri LzteraWre, 31 135S-1393; and more recent research by Stryker and Pandolfi (1997), Sacks and Warner, 1996 , :Sources of Slow Growth in African Econorru*es," HIM Development Discussion Paper No. 545.
Stryker and Pandolfi (1997), Sachs and Warner (1996)

Costs of Policy Interventions

The costs entailed in achieving political stability, democratization and trade openness are difficult to quantify since most of the difficulty in effectuating these reforms is not the direct cost but rather costs entailed in the political and economic repercussions on diverse interests within society. As policy decisions, the marginal costs of each intervention are arguably close to zero) since op, - action of the policy apparatuses in each country is likely to be incurred whether: the correct policies are introduced or not. On the other hand, it may be argued that choice of correct policies will require training of policy makers to understand the logic and requirements of sustaining openness. Direct training/technical assistance costs have been roughly estimated from past technical assistance contracts that have focused on national trade and macroeconomic policy change. Costs are assumed to be proportionate to the magnitude of the policy change required, and to increase with the population of the country, but at a less than proportionate rate. Appendix Table A.5 presents assumed training/technical assistance package costs for each country or region to achieve the desired goals.

Both political inertia and opposition to policy changes are certain to require pressure to overcome them. To some extent this pressure may materialize as the value of these policy changes becomes better understood. Moreover, to the extent that the sectoral and subsectoral level initiatives of the food security initiative are contingent on these policv changes, the 'incentive of these programs will also provide inducement to change. However, past experience has demonstrated that external forces cannot orchestrate this pressure, rather, domestic policy makers must back policy reform.

Sector-Level Interventions

Intervention 5: Rural Roads

Logic: Rural road density has been shown to be among the most important contributors to productivity growth agriculture. This is due, first, to the impact that better roads have in reducing the transport component of input costs and transaction costs of marketing products. In addition, however, roads improve the flow of information on market conditions, new technologies, and potential hazards and risks to their enterprises. Rural roads also improve the competitiveness of nonfarm rural activities and increase access to public and private services that support the rural economy. Thus through these multiple and diverse effects, numerous studies have found that good rural roads are a necessary complement to the success of other activities in rural areas.

[Cf. Assumptions of ERS. , International Agricultural Baseline Projections to 2005. May, 1997, USDA/ERS. I Strauss and D. Thomas, Ch34. Human Resources: Empirical Modeling of Household and Family Decisions, Handbook of Development Economics, Vol. 3.A (Amsterdam: North Holland 1995) pp. 1894-1895.]

The model traces only the most important of these links, the act of rural road investment on agricultural labor productivity. This, in rum, is assumed to have a multiplicative effect on aggregate national income. Income growth is then assumed to

The cost of reforms is modeled by a function that relates the square root of the population to a standard technical assistance package cost. The basic technical package assumes that a country with a population of 100 million people would require 100 million dollars over the fifteen-year period to implement a complete set of policy reforms in political stability, democratization or economic openness. Each function is also weighted by the extent to which the country has already converged with the sought after reforms. Thus countries or sub-regions which have the furthest to go make the most cost-effective progress in policy reform influence child undernutrition through the three underlying effects measured by Smith and Haddad (Table 2).

In addition to income effects, improvements in agricultural productivity are also expected to directly increase food availability, as a function of the share of agricultural productivity improvements, which are assumed to accrue to food crops. This direct effect is therefore added to the *income effect on food availability and then translated into an impact on undernutrition..

Data and Assumptions -- Appendix Table A.2 presents estimates of rural road densities, and agricultural productivity from which impacts are derived.' Craig, Pardee and Rosebloom (1997) have measured the i act of rural roads on agricultural productivity from cross-country data for developing countries. Their data V1*eIds a road density elasticity of agricultural labor productivity of .09. In this analysis, this elasticity has been to .2 to incorporate the contribution of roads to the efficacy of other factors which contribute to agricultural productivity (animal and tractor traction, fertilizer use), but which have not been included in this analysis. Evidence of a stronger effect is corroborated by Fan, Hazel, and Thorat (March, 1998) et al, for India, who find very high multipliers for total factor productivity due to road density. Using the data for the subset of countries/subregions for rural road densities and for agricultural productivity, 'an intercept parameter was sub-estimated for a function relating the two series.

As noted above, the impact on agricultural labor productivity is assumed to translate directly 'into an 'increase in agricultural product. This in turn is assumed to impact on general income in the economy. Various studies have evaluated this multiplier for different countries of the world." Spencer summarizes this evidence, giving multiplier ranges of 1.5 to 2.7 for Sub-Saharan Africa and 1.5 to 2.4 for Asia. Based upon his assumptions, the model assumes a multiplier of 2 for all countries.

Translating agricultural productivity into changes in food availability is made by a parameter, which assesses the share of improvements in agricultural productivity, which can be assumed to accrue to food crops. Because investments in agricultural research are expected to go to cash crops as well,the assumption made in the analysis is that the impact on food products is half the effect on overall agricultural output

[Footnotes: 8)Data on rural road density is taken from the World Bank World Development Indicators, 1998. Agricultural Productivity data is taken from Timmer (1997) and, where absent from his estimates, interpolated from data on the agricultural share of GDP and the rural labor force.
9) This technique evaluates the intercept b, as follows:
bo - 1/n 1 [In (A) - b, In(R) I where n is the number of observations in the series, A is the agricutlural product per capita rural labor, R is rural road density and bl is the known partial elasticity relating the two. Obviously, the equation assumes that bi is a general elasticity, however, what is important is that it yields an intercept that is representative for the sample chosen such that in the model, the impact of large changes in R result in realistic changes in A. (10)" See Dunstan Spencer, 1994, and also Block and Timmer, 1994.].

Cost: Rural road construction costs were obtained from the World Bank for construction of rural roads." Costs per kilometer of laterite roads range between 10 and 80 thousand dollars (1998) depending on terrain, distance to sources of material and other factors. However, as a general mean, $20, 000/km was assumed, representing an all-weather laterite road built for savanah zones sufficient to accommodate 10 to 40 veliides per day.

Intervention 6: Agricultural Research

Logic: Agricultural research is crucial to sustaining agricultural productivity growth in the medium to long term. As with rural roads, its impact on undernutrition is traced through its impact on agnicultural productivity, which then has a multiplicative effect on national GDP Per/capita income growth then affects the underlying causes of under-nutrition.

In addition to these effects, as with rural roads, agricultural research is also assumed to increase caloric availability directly through its impact on food production.

Data and Assumptions: The level of current agricultural research has been taken from estimates by Pardee, et, al, for Sub-Saharan Africa. For other regions and countries, this data was not available and therefore a rough estimate was derived from World Development Indicator data. The derivation assumed that .6% of GDP goes to research and development *in each country/region. This parameter is an average for a subsample of developing countries in the data set for which the 'information exists. The share going to agriculture was then assumed to be proportionate to agriculture's contribution to GDP in each country. The

resultant absolute amounts and amounts per capita are reported in Appendix Table A.2 for each country or region. Data assumptions for agricultural productivity, and impacts on national *income and then on underlying causes of undernutrition are identical to those used for the rural roads analysis (Intervention 6).

An elasticity of .1 was used to link agricultural research to agricultural productivity growth in all countries. This parameter was borrowed from the analysis by Craig, Pardee, and Rosebloom (1997).2 As 'in the case of rural roads, an 'intercept parameter was estimated to adjust the elasticity effect to the specific data used in the analysis. The linkage between agricultural productivity and natural income, and between natural income and child malnutrition, was assumed to be the same as for rural roads.

As with rural roads, increases in agricultural output are assumed to have half as great an impact on food production in percentage terms.

Cost: Investments in agricultural research represent their costs directly. Regarding the timing of these investments, however, there is typically a substantial lag between the instigation of agricultural research and its impact on productivity. For this reason, all agricultural research investments are assumed to be invested in the first five years of the initiative, allowing ten years for them to come to fruition. In addition, it is assumed that research is adaptive 'in nature and targeted to facilitating technology transfer, so gestating periods are not long.

Household Level Interventions

Intervention 7: Targeted Food Aid

Logic: The targeted food aid intervention is assumed to be a direct transfer to populations at high risk of undernutrition who are participants in maternal and child health care programs. To evaluate the impact of these transfers, the analysis assumes that the transfer must be sufficient to permanently remove an individual from the ranks of the undernourished. To do so, the transfer must contain an investment component sufficient to sustain the individual’s income in perpetuity at a level above the threshold of food security. The analysis does not specify what these investments might be; they might include

investment in human capital through education (Intervention 7), access to water or other infrastructure which permanently reduces the risks of undernutrition (Intervention 7), or direct investments in productive activities such as agriculture. It is assumed that NGO's will be heavily involved 'in deciding how these transfers are to be spent. While this approach substantially increases up-front costs, it also assures sufficient transfer per capita to insure that the impact will be permanent.

Data and Assumptions: To determine the annual income transfer necessary to remove a person from undernutrition, the analysis relies to the poverty gap measure. This measure is the aggregate average daily shortfall from the poverty line of people below this line. Moving a person above the poverty line is assumed to also remove the 'individual the ranks of the undernourished since the line is defined to be the *income level below which an individual does not have sufficient entitlement to the basic necessities of life."

The analysis assumes that the transfer moves one-half of those below the poverty line to a position above the line. The capital requirements to generate the annual cost of doing this is estimated using a capital-output ratio of three. Appendix Table A.3 presents assumptions regarding the poverty gap, and the necessary income transfer needed to reduce the undernourished by one person for each country/sub-region considered 'in the analysis.

In addition, the income transfer is discounted by a factor (0.75) to reflect the inefficiencies involved in using food aid to transfer income to targeted groups. This efficiency parameter is projected to be higher than has been the case in the past (.6) due to two expected improvements in targeted food aid transfers. First, the rapid development of information technologies such as smart cards, telecommunications, and the internet are expected to increase the efficiency of conducting and monitoring income transfers, to improve targeting of the transfers to the undernourished, and to reduce losses due to fraud that are typically associated with such subsidy schemes. Second, the sale of food aid to generate income for transfers is expected to be handled to a much greater extent by large experienced multinational grain traders. These traders are expected to be more efficient than the NGOs who currently

monetize most food aid because the grain companies can exploit economies of scale in storage, shipment and marketing, and can obtain better prices on world markets.

Intervention 8: Female Secondary School Education

Logic: The impact of female education on undernutrition operates through a variety of channels. First, better-educated women know better how to care for their children, with respect to health and diet. Secondly, they are more likely to practice family planning successfully, which allows for better birth spacing and ultimately smaller families. Both of these effects improve the food security prospects for the children which are born. Moreover, schooling, particularly secondary education, imparts greater status on women, and therefore empowers them within society to make greater demands for their families. Finally, education has the obvious effect of improving the income earning potential of the family and thereby increases its entitlement to food.

Data and Assumptions -- Smith and Haddad have found that for every 10-percentage points of increased female secondary school enrollment, child undernutrition falls by 1.7 percentage points. This relationship is used directly in the model. (See Table 2.)

The timing of investments in female education are assumed to occur in the first five years in order to allow greater education to impact households as better educated girls become mothers. Investment costs are assumed to be recurrent in order to sustain the percentage increase in female secondary school education.

The cost of female secondary school education assumes S52/female /year in SubSaharan Africa and $35/female/year in Asia and the rest of the world. These data are taken from Sumrners, 1994.

Intervention 9: Access to Safe Water

Logic: Safe water is known to dramatically reduce exposure to a variety of debilitating diseases that directly obstruct the intake and utilization of food by the body. These diseases include dysentery, and internal and external parasites among others. In addition, easier access to safe

water reduces the time of hauling water, and therefore increases the productivity and ultimately the status of women, whose work typically included, providing water to the household. Improvement in access to safe water therefore has both direct and indirect effects.

Data and Assumptions: Smith and Haddad found that a ten-percent improvement in access to safe water reduces child undernutrition by 0.8 percentage points. Investments in safe water are assumed to be feasible at any point in the planning horizon to 2015. Moreover the impact on the undernourished is assumed to be permanent because investments in safe water infrastructure are assumed to last for more than the 15 year impact period.

Data on current rates of access to safe water are provided in Appendix Table A.3. The World Bank has estimated the cost of providing safe water at $15/person in rural areas of developing countries. These costs cover well digging or provision of accessible water point sites, which provide uncontaminated or treated water. Investments to provide access to safe water for purposes of food security are limited in the model, however, by the fact that by the year 2015, even without exceptional investments by the donor community, most countries are projected to have provided safe water to more than 80% of their households."

For safe water, as with female education, the model includes an override such that investments M improving safe water cannot exceed the number of people who lack safe water.

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