

**MEETING THE FOOD SUMMIT  
TARGET THE UNITED STATES  
CONTRIBUTION**

**GLOBAL STRATEGY**

**September 1998**

**APAP III  
Research Report  
No. 1039**

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**AGRICULTURAL POLICY ANALYSIS PROJECT, PHASE III**

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**Prepared for**

**Agricultural Policy Analysis Project, Phase III, (APAP III)**

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# **MEETING THE FOOD SUMMIT TARGET THE UNITED STATES CONTRIBUTION**

## **GLOBAL STRATEGY**

prepared by

**J. Dirck Stryker  
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with the assistance of

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Prepared for

**Office of Economic Growth and Agricultural Development  
Global Bureau  
U. S. Agency for International Development**

*Views presented here do not necessarily reflect the official position of the U. S. Government*

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## PREFACE

To make the commitment to end world hunger was a challenge set forth by the leaders of the world at the 1996 World Food Summit. As an intermediate goal, the summit put forward the objective to reduce the number of undernourished people in the world to 400 million by the year 2015.

Based on a challenge set forth by U.S. Agency for International Development (USAID) commissioned the Agricultural Policy Analysis Project, Phase III (APAP III) to develop an economic foundation and strategy for meeting the Food Summit target. Discussions of the undertaking began as part of the seminar on “Agricultural Policy Reform, Growth and Food Security: Preparing for the 21<sup>st</sup> Century” sponsored by USAID and organized by APAP III.

J. Dirck Stryker and Jeffery C. Metzler of APAP team member Associates for International Resources and Development (AIRD) provided leadership in undertaking the analysis, and preparing this strategy and the accompanying proposed initiative. They worked closely with Mark D. Newman, A. Ray Love, Gordon A. Straub and Wallace E. Tyner at Abt Associates, and consulted with a number of international experts from a variety of academic and research institutions. These experts included Michael Weber, Michigan State University; Terry Roe, University of Minnesota; Robert Paarlberg, Wellesly College; Peter Timmer, Harvard Institute for International Development; Kimberly Chung, Brown University; Per Pinstrup-Anderson, Mark Rosegrant, Peter Hazell, Phillip Pardey, Lawrence Haddad, and Lisa Smith, International Food Policy Research Institute; and Cheryl Christensen and Shahala Shapouri, Economic Research Service, USDA.

Preliminary findings were discussed and adapted in a series of focus groups organized by USAID with interested agencies in Washington, D.C., including the State Department, under the guidance of Food Security Coordinator, Lynn Lambert; USDA with input from “Buzz” Guroff, Mary Anne Keefe, and staff in the Economic Research Service; NOAA; and others. The primary conclusion from these discussions was that real progress in meeting the Food Summit objective will require an increased commitment of U.S. resources as well as close collaboration with other donors, financial institutions, private business and NGOs.

Based on feedback and further analysis, Dr. Stryker’s team worked with USAID officials to develop the following Global Strategy to achieve the Food Summit target and the accompanying Proposal for a Presidential Initiative.

Mark D. Newman, Technical Director  
APAP III

Gordon A. Straub, Project Director  
APAP III

## SUMMARY

The World Food Summit in 1996 established the target of reducing by the year 2015 the number of undernourished people in the world to one-half the level that existed in the early 1990s.<sup>1</sup> In broad terms this means reducing the number of undernourished from in excess of 800 million to a target of 400 million. Although recent trends suggest that the percentage undernourished is currently falling in most areas of the world, the same cannot be said of the absolute level of undernourished unless there is an increased effort to achieve this target. Furthermore, even the percentage of undernourished is projected to rise in some countries, especially in Sub-Saharan Africa.

Within the United States, an Inter-Agency Working Group (IWG) was created after the Food Summit to prepare an Action Plan in support of the achievement of this target not only at the global level but also on the domestic front. In elaborating this plan, the IWG met with numerous organizations such as NGOs, private firms, universities, foundations, and government agencies at the federal, state, and local levels. The Action Plan that resulted has a number of key features.

- Emphasis on an open trade and investment policy environment, sound food security policies, and a participatory decision-making process – all seen as essential to stimulating the required foreign and domestic investment.
- Re-negotiation of the Food Aid Convention to establish acceptable and feasible food aid levels.
- Continued liberalization of world trade, including free trade in food and biotechnology products.
- Support for research, education, and extension related to agriculture and nutrition in the U.S. and overseas, with emphasis on production, processing, and marketing systems that are environmentally sustainable.
- Support for food safety nets through domestic food assistance and international food aid programs.
- Improvement of information systems designed to monitor food security.
- Enhanced food and water safety.
- Support for food security as a basic human right, though recognizing that this “need not lead to development of any additional legally binding international agreement.”

The plan recognizes the need for a differentiated approach by region, for taking advantage of the United States’ comparative advantage in certain types of assistance, for coordinating with other donors, and for prioritizing actions.

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<sup>1</sup> This report concentrates on the problem of undernutrition resulting from lack of adequate absorption of calories by the human body, in contrast to malnutrition, which may be due to deficiencies of protein or micro-nutrients as well. Although the problem of micro-nutrient deficiency is severe in some parts of the world -- especially for vitamin A, iron, and iodine – the solutions to this problem are quite different from those for overcoming calorie deficiency. Furthermore, the Food Summit target is defined solely in terms of calorie deficiency, so this seems the appropriate measure to be used here.

It soon became apparent, as the plan was being prepared, that additional budgetary resources were not going to be available for implementation of the plan. As a result, it has been constrained to describing how the United States intends to fulfill its commitments by strengthening what is already being done to reduce hunger and malnutrition at home and abroad *within the normal budgetary process*. This leaves room, however, for the proposal of a Presidential Initiative to seek additional resources.

Such an initiative requires an analysis of the prevalence and causes of world undernutrition, an assessment of alternative approaches for achieving the Food Summit target including their cost effectiveness in meeting this goal, an analysis of the comparative advantage of the U.S. over other donors in working towards the target, and the specification of a strategy for the U.S. to pursue. This is the subject of this report. The proposal for a Presidential Initiative will go beyond this to specify the specific elements of the U.S. strategy and what their costs will be, why the U.S. should undertake these actions rather than other donors, what the impact of these actions will be on undernutrition, and why the U.S. will benefit.

This report begins with an assessment of recent levels of undernutrition by major country and sub-region. It then projects to the year 2015 the number of undernourished in the world assuming no increase in the actions taken to reduce this number. These projections are based on forecasts of child malnutrition extrapolated to the entire population. The causes of undernutrition are then assessed for 14 major countries and sub-regions of the world, followed by a discussion of the consequences of world hunger for the international community, including the United States.

The report then goes on to examine the opportunity that currently exists for alleviating hunger and meeting the Food Summit target. Alternative interventions for achieving this goal are described and their cost effectiveness is estimated. The report concludes that the total cost of reaching the target could be less than \$45 billion. Stretched out over 15 years, this amounts to no more than 5 percent of the current annual level of Official Development Assistance.

The report goes on to look at the U.S. comparative advantage in reducing world hunger. This assessment is combined with the cost effectiveness analysis of alternative interventions to yield a U.S. strategy for meeting the Food Summit target -- a strategy in which the U.S. concentrates its interventions, beyond those already being undertaken, in South Asia and Sub-Saharan Africa.

The report concludes with the following observations:

- If no additional action is taken, world undernutrition is expected to increase in absolute terms by the year 2015.
- There is a unique opportunity for U.S. global leadership in meeting the Food Summit target at the turn of the millennium.
- A viable and affordable strategy exists for achieving this goal.
- This strategy draws upon the combined experience of U.S. farmers, agribusiness, NGOs, universities, foundations, and the U.S. government.

## PREVALENCE OF UNDERNUTRITION

In the 1995, the number of undernourished in the world totaled about 854 million.<sup>2</sup> This figure is expected to increase to about 915 million by the year 2015 unless further action is taken. This does not imply that no progress is being made in reducing world hunger. In many areas of the world, the percentage undernourished is decreasing. This is not true everywhere, however, and even where it is true, growth of population often results in increased absolute numbers of undernourished.

Particularly striking is the distribution of the percentage of undernourished across regions and countries, as shown in Map 1. These figures relate to data on child malnutrition, which better indicates physical status than do estimates of chronic undernutrition derived from data on food availability (see Footnote 2). They show high rates of undernutrition in Sub-Saharan Africa (SSA), South Asia, and some parts of Southeast Asia. Rates are relatively low, for the most part, in North Africa, South America, and the Middle East. They are somewhat higher in Central America and parts of the Caribbean.

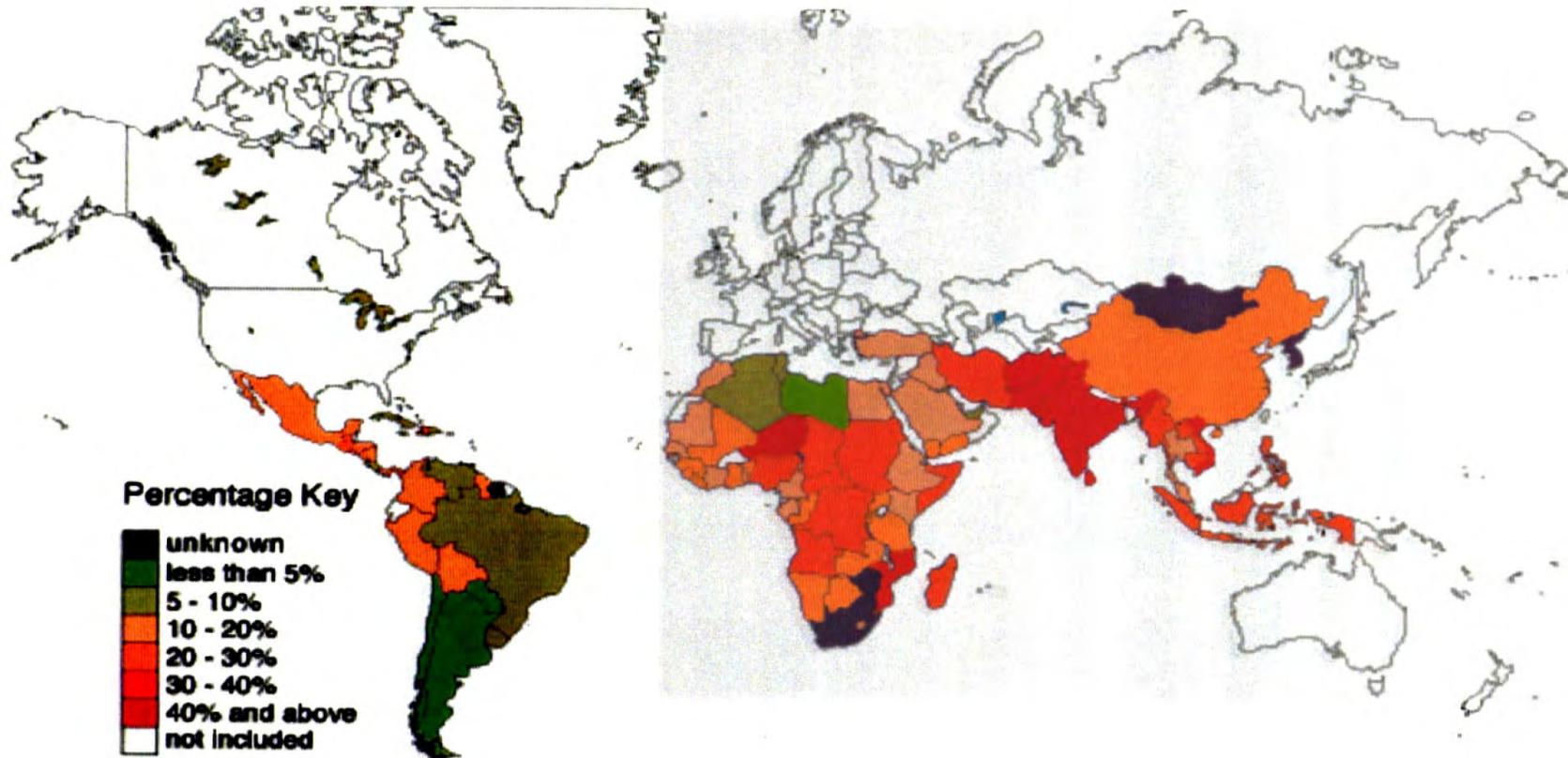
Map 2 shows projected rates of child malnutrition by country in the year 2015. These projections are based on the equation used by the International Food Policy Research Institute (IFPRI) to project child malnutrition based on IFPRI's Vision 2020 projections of food availability. The projections of child malnutrition based on food availability have been modified to allow for estimated changes by the year 2015 in women's rates of secondary school enrollment and in the percentage of the population with access to safe water.

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<sup>2</sup> This figure differs somewhat from the number estimated by FAO of 841 million undernourished in 1990-92. The FAO estimate is based on food availability calculated from food balance sheets with an adjustment for the distribution of food intake within countries. A minimum requirement is established for each country, and the percentage of the population falling below this requirement is considered chronically undernourished (FAO, 1996). In contrast, the number reported here is based on the percentage of children underweight in 1988-92 from Smith (1998), adjusted for population change to 1995 and extrapolated to cover the entire population (see Annex A for the methodology). Although the two numbers do not differ very much in total, the differences are much larger across regions. In particular, undernutrition is much greater in South Asia than would be predicted by the data on food availability. The FAO is well aware of this, having published child malnutrition data obtained from anthropometric surveys in addition to the estimates of chronic undernutrition from data on food availability (FAO, 1996).

# Map 1

## Current level of Undernutrition 1990-1995 (% children underweight, WHO)



Source: FAO, The *Sixth* World Food Survey.

## Map 2

### Year 2015 Projection of Undernutrition (% children underweight, WHO)



Source: AIRD estimates see Appendix A.

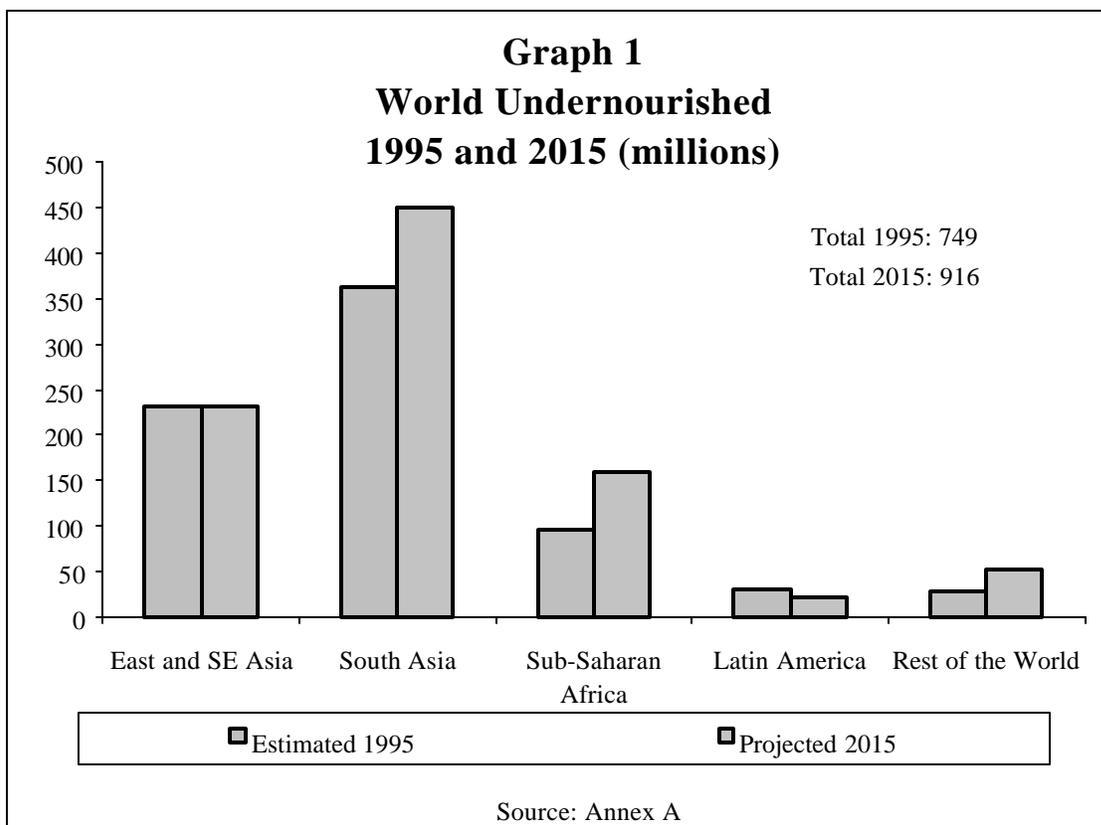
Maps 1 and 2 indicate relative rates of undernutrition, but they do not show where the absolute level of undernutrition is greatest. For this to be meaningful in terms of the Food Summit target, undernutrition has to be measured for the entire population. Accordingly, actual rates of child malnutrition for 1995 and projected rates for 2015 were extrapolated to the entire population using the methodology described in Annex A, and the results were then expressed in absolute terms, as shown for each of the major regions in Graph 1.<sup>3</sup>

This graph shows that most of the world's undernutrition is concentrated in Asia. The results are very different, however, for South Asia as compared with East and Southeast Asia. With the exception of a few countries in Southeast Asia, such as Indonesia, Philippines, and Vietnam, where the incidence of undernutrition is still quite high, undernutrition in the region is either low or is decreasing fairly rapidly. Even these three countries are witnessing a steady decline in undernutrition. In South Asia, on the other hand, more than 50 percent of the children under five years of age are undernourished, as measured by weight for age, in Bangladesh, India, and Nepal. The percentages in Pakistan and Sri Lanka are also high. Although the prevalence of undernutrition is decreasing in many of these countries, the absolute numbers of undernourished are rising.

Sub-Saharan Africa is the other region where there is substantial undernutrition. Many of the countries in which undernutrition is highest have experienced major war and civil strife in recent years. Examples include Angola, Ethiopia, Mozambique, Rwanda, Somalia, and Sudan. Other countries, such as Central African Republic, Chad, Congo, and Madagascar, have been persistently poor and underdeveloped. The trend in most of these countries is for a continued increase in the absolute number of undernourished, and also in many cases in the relative prevalence of undernutrition. On average, for example, the number of undernourished in Africa is projected to increase by 50 percent over the next 20 years.

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<sup>3</sup> Country details are presented in Annex A.



## CAUSES OF UNDERNUTRITION

The causes of undernutrition are multiple and complex. They include limited availability of food within a country or region, weak access of household and individuals to food, and poor utilization of food by individuals.<sup>4</sup> Among the critical variables are:

- food availability, which equals production plus imports minus exports, with adjustment for changes in stocks and for feed, seed, and losses;
- per capita real GDP at the national level, which is related to the ability of households on average to grow or purchase food, but is also related to the ability of governments to provide facilities for education and health, which also have an influence on nutrition;
- depth of poverty, which shows the degree to which some households are below the poverty line regardless of the overall national level of per capita income;

<sup>4</sup> Rodgers (1990); Schnepf (1991); and Haddad et al. (1997)

- illiteracy among women as a measure of the education and status of women, which are important variables influencing intra-household allocation of food;<sup>5</sup>
- access to safe water and sanitary facilities, which is an important measure of the health of the population, especially in humid areas with high population density, where endemic parasitic and other diseases inhibit the ability to absorb nutrients from food that is ingested.<sup>6</sup>

Graphs 2 through 6 show the levels of each of these variables for East and Southeast Asia, South Asia, Sub-Saharan Africa, Latin America and the Caribbean, and the Rest of the Developing World. More detailed tables for 14 countries and sub-regions are included in the Appendix Tables of Annex A.<sup>7</sup>

Graph 2 shows the level of per capita food availability, expressed as Dietary Energy Supply (DES) in kilocalories per day, in 1990-92 (FAO, 1996). East and Southeast Asia clearly has the highest level, followed closely by Latin America and the Caribbean. South Asia is substantially behind these regions but is well ahead of Sub-Saharan Africa. A similar picture emerges from Graph 3 with respect to per capita real GDP, measured in 1985 purchasing power parity prices. Within Africa, however, the developing nations have an average per capita GDP of \$1,646, while the war-torn and least developed nations have a per capita GDP of \$644 and \$666, respectively.

Average per capita real GDP is only one indicator of poverty since it does not take into account the distribution of income within a country. A better measure is the depth of poverty, defined as the cumulative gap by which income of poor household falls below the poverty line. This variable, taken from the World Bank (1998), is shown in Graph 4. It suggests a substantial degree of poverty within South Asia and Sub-Saharan Africa, especially the least developed countries of SSA.

The low status of women in South Asia is demonstrated in Graph 5, which shows the very high female illiteracy rates that prevail there. Illiteracy is also high for women in SSA, though the difference between the rates for women and men is not as great as in South Asia. Finally, Graph 6 suggests the importance of health problem in all regions arising because of low rates of access of the population to safe water and sanitation.

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<sup>5</sup> King and Hill (1993) reviewed the state and implications of women's education and the extent of the gender gap in education for 152 countries covering the period 1960 through 1985. They also seek to understand why gender gaps exist; Mark Pitt (1995) evaluated the direct and indirect effect of mother's education on child health for 14 Sub-Saharan African countries; Paul Glewwe (1997) has empirical evidence from Morocco that suggest that women primarily use the literacy and numeracy skills acquired in school to assist them in diagnosing and treating child health problems or interacting with health care providers. This also suggests that direct teaching of health knowledge skills in school could substantially raise child health and nutrition.

<sup>6</sup> Empirical evidence from Rwanda hints at the importance of health infrastructure and sanitary environment in the nutritional status of household members (Schnepf 1991)

<sup>7</sup> The breakdown of these more detailed tables is as follows: China, Indonesia, Rest of East and Southeast Asia, Pakistan, India, Bangladesh, Rest of South Asia, Ethiopia, Nigeria, War-Torn Sub-Saharan Africa (SSA), Least Developed SSA, Developing SSA, Latin America and Caribbean (LAC), and Rest of World.

In summary, on the basis of these graphs and the more detailed tables in Annex A, we can define the broader dimensions of the principal causes of undernutrition in different regions. In South Asia, which has the highest levels of absolute undernutrition in the world, the problem is not so much inadequacy of food supply, except possibly in Bangladesh. Nor is it one of very low levels of per capita real GDP. Rather it appears to be due to a constellation of interacting factors:

- deep poverty among the rural landless and other particularly vulnerable groups in the society, which results in their failure to gain adequate access to food;
- low education and social status of women, which results in their having little command over the distribution of food to women and children within the household;
- high population density, a humid monsoon climate, and poor access to safe water and sanitation, which leads to poor health and inhibits the utilization of ingested nutrients.

One result is a failure of data on food availability (DES) to accurately predict the extent of undernutrition in South Asia.

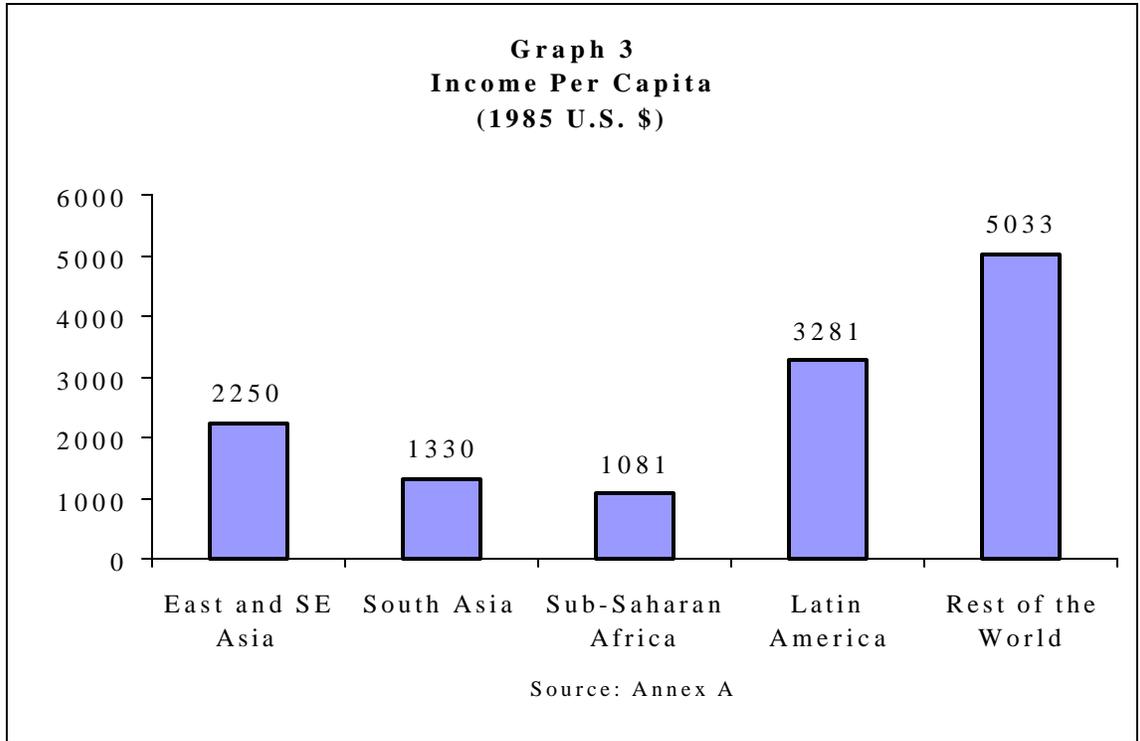
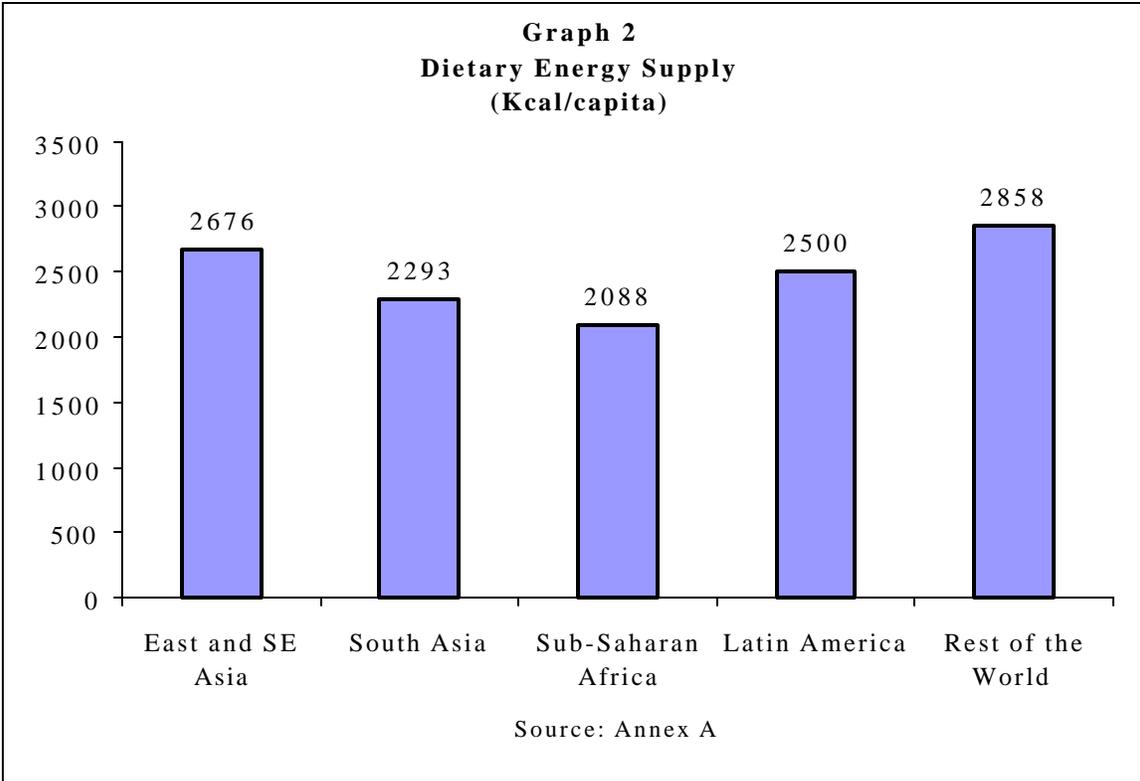
In Sub-Saharan Africa, on the other hand, the problem is much more one of low levels of food availability and low average per capita real GDP, especially in the war-torn and least developed countries. This leads to poverty not so much because of inequality in the distribution of income and wealth but because there is little income and wealth to distribute. Education and health are also problems, but these are due more to low levels of real GDP than to discrimination against women and people living in rural areas. In fact, generally low levels of population density make African populations somewhat less sensitive to the health problems posed in South Asia by lack of safe water and sanitation.<sup>8</sup>

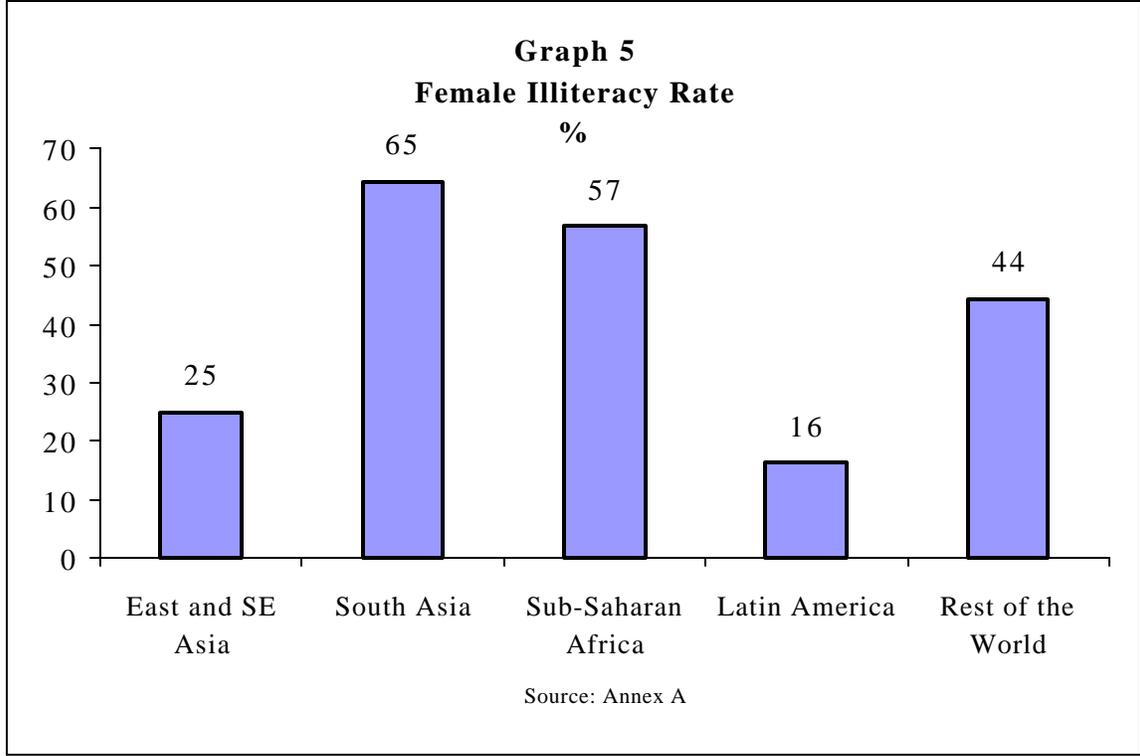
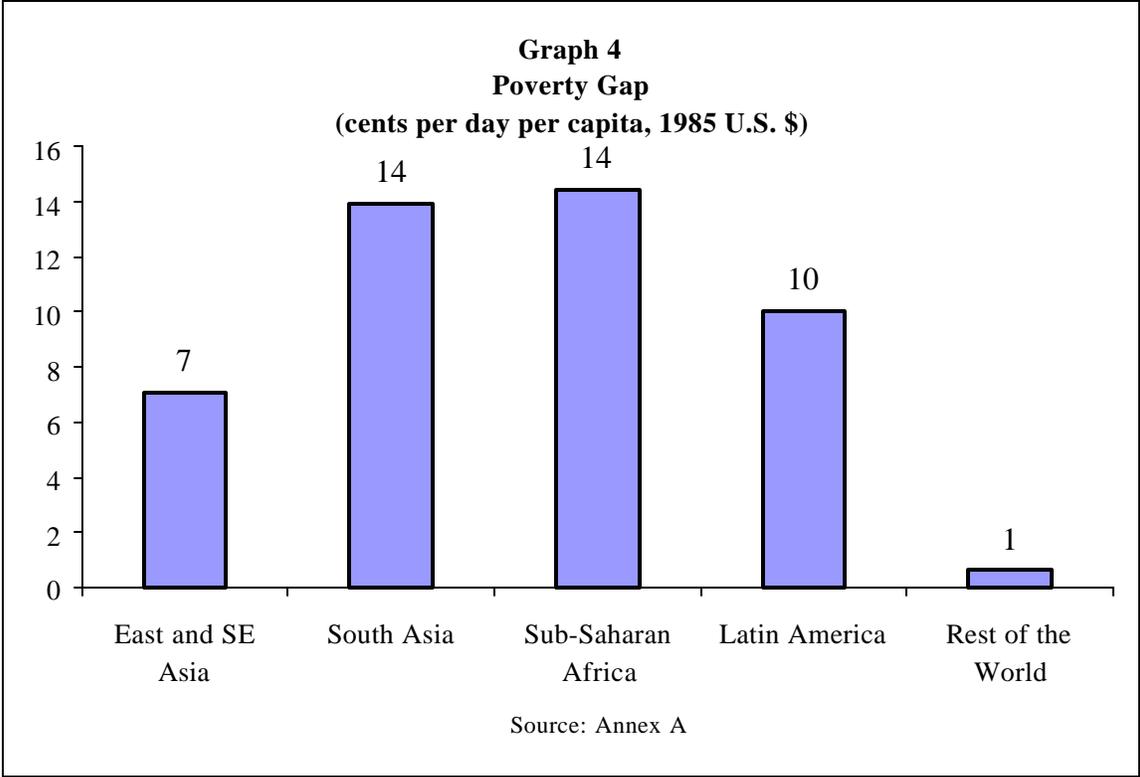
East and Southeast Asia is characterized generally by high levels of food availability, high per capita real GDP, and low levels of poverty in relation to other regions. Women's education and social status are generally better, and there is greater access to safe water and sanitation. Furthermore, the evidence suggests that undernutrition is decreasing in this region, both absolutely and in relation to the total population. Thus the problems in this region are more those of a few specific countries that have yet to partake fully in the growth process than of dealing with widespread undernutrition on a regional scale. Although many of the Asian economies have recently been weakened by a series of financial and other crises, these are not expected to be problems that will have a major long run impact on undernutrition (IFPRI, 1998).

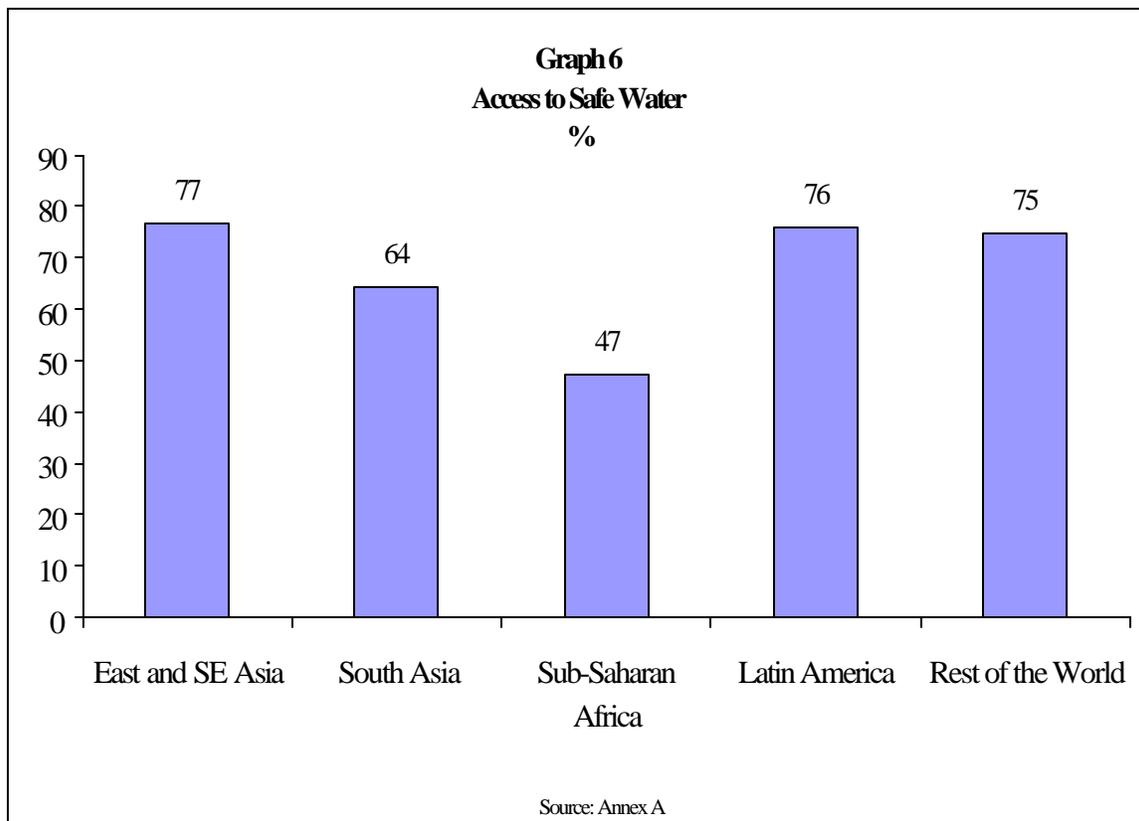
In Latin America and the Caribbean (LAC) and in the Rest of the World, the picture is one of generally adequate food availability, on a par with East and Southeast Asia. Per capita income is much higher than in the other developing countries, but the poverty gap in LAC is considerably higher than would be expected from this average income level, suggesting the possibility of important pockets of undernutrition. In addition, although female illiteracy is relatively low in LAC, it is quite high in the Rest of the World, most of which is Muslim, indicating the possibility of undernutrition within households.

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<sup>8</sup> Africa, of course, does have major health problems associated with AIDS, malaria, and parasitic diseases.







## CONSEQUENCES AND OPPORTUNITIES

The consequences of the high levels of undernutrition that exist in the world are severe. Above all they are severe for the more than 800 million people that suffer from chronic hunger. Aside from their physical distress, these people are less able to work, reducing the income they can earn for themselves and for the nation. Poverty and undernutrition thus play upon one another in a viscous cycle that has a number of adverse results.

First this viscous cycle can lead to political and military crisis. There is substantial evidence that even if poverty and undernutrition are not the proximate causes of these crises, they are often at least contributing factors (Messer, Cohen, and D’Costra, 1998). Furthermore, the cost of dealing with crisis is often far higher than what would have been necessary to avert the crisis in the first place.

Second, chronic undernutrition creates conditions of uncertainty regarding emergency food aid. Where large numbers of people are already undernourished, the margin for error in dealing with the consequences of drought, war, and other disasters is comparatively slim. As the world, and particularly the United States, moves away from food aid drawn upon surplus stocks and towards food aid as a budgetary expenditure, this

leads to greater uncertainty regarding the fiscal and logistical requirements of emergency food shipments.

Third, poverty and undernutrition feed upon one another in ways that limit the development of local markets for food. This decreases the reliability of markets in these countries for exports from the food surplus countries such as the United States. As production continues to increase in food exporting countries at rates faster than the growth of domestic consumption, these countries must rely increasingly on the expansion of markets in developing countries. Whatever inhibits the growth of these markets and makes them less reliable acts as a disincentive to agricultural research and production, which makes the world potentially more vulnerable to global food shortages.

Finally, the viscous cycle of poverty and undernutrition sets back the spread of democracy and good governance to the developing nations. People who are hungry, unproductive, and deprived have a difficult time looking out for their own interests. This encourages corruption, lack of transparency, and poor governance.

The establishment of the Food Summit target presents a unique opportunity to act effectively to break this viscous cycle. The target is visible, measurable, and attainable. It can be achieved, as this report demonstrates, without enormous financial sacrifice. All it requires is strong commitment and global leadership. The moment is particularly appropriate, moreover, because of the President's recent trips to Africa, Asia, and Latin America – demonstrating the commitment that the United States has to the developing world.

The moment is also appropriate because of a confluence of other factors. First, the U.S. agricultural community has developed a strong global perspective regarding its own self-interests. Gone are the days when this community pressed for high domestic prices and accumulation of food stocks. Today U.S. agriculture is primarily interested in stimulating overseas demand for U.S. farm products. But this is also what is needed to promote food security in developing countries by raising incomes and improving markets for food.

Second, the policy environment in many developing countries has improved enormously over the past 15 years. Trade and exchange rate policies are more open, trade taxes have been lowered, fiscal deficits have been reduced, markets have been freed up, and legal and regulatory environments are more conducive to private sector investment and productive activity. This means that interventions to increase food security through productive investments that may have failed 15 years ago are much more likely to succeed today.

Finally, the world is currently experiencing, at the global level, a period of peace and prosperity that has not existed for almost a century. Despite the economic crisis in Asia and the wars and other conflicts in Africa, lower expenditures for national defense and unprecedented economic prosperity in most of the world create the best opportunity in at least a hundred years to do something significant about world hunger.

## LEVELS OF INTERVENTIONS

There are a number of different levels at which interventions can be undertaken to alleviate hunger and undernutrition. These levels may be global, national, sectoral, or household. Some examples are illustrated in Table 1.

**Table 1**

<b>Interventions to Reduce Undernutrition</b>	
<b>What is needed</b>	<b>How to achieve it</b>
<b>Global</b>	
Secure access to food in world markets	International agreements
Peace and physical security	Conflict prevention and recovery
<b>National</b>	
Promote democracy in rural areas	Civil participation and advocacy
Enabling environment	Macro, and trade and legal reform
<b>Sectoral</b>	
Rural production and marketing infrastructure	Public investment in roads
Increase farm productivity	Private technology transfer and public agricultural research
<b>Household</b>	
Raise entitlement to food	Targeted food aid
Empower women	Women's education
Improve rural health conditions	Safe water and sanitation

At the global level it is important that sufficient food be produced to feed the world's population adequately. It is also important that global markets and other institutions operate effectively to permit food to move reliably from areas of surplus to areas of deficit. This requires a host of international agreements and other measures, such as those coming under the World Trade Organization.

At the national level, it is essential that there be peace and a high degree of physical security if food supplies are to be transported safely within the country and if stocks of food are to be secure. This requires conflict prevention and resolution whenever possible. Where conflicts do arise, their speedy resolution and the economic recovery of the countries concerned should be a high priority. Research shows that the undernutrition resulting from war and civil strife is high and that the costs of dealing with it through emergency food aid are also high (Messer, Cohen, and D'Costa).

Other interventions at the national level include the promotion of democracy in rural areas and the creation of an enabling environment for trade and investment. The promotion of democracy through civil participation and advocacy can be important in creating the conditions for the sustainable use of natural resources, especially those that are collective nature. This helps to increase the availability of food. Effective political advocacy also helps to ensure that the rural population receives its fair share of rural infrastructure, such as roads, irrigation works, schools, health facilities, and safe water

and sanitation. This can have an important influence on agricultural productivity, education, and health, all of which favorably influence nutrition.

Research has shown that a policy environment opened to international trade and investment is important for higher rates of economic growth (Sachs and Warner, 1996). This, in turn, has a favorable effect on food availability, women's education, and access to safe water and sanitation, all of which reduce undernutrition. In addition, countries can benefit by reducing trade taxes and other barriers to food imports, which lowers food prices and increases real incomes used to purchase food.

At the sectoral level, the two most important types of interventions are investment in productive rural infrastructure and in agricultural research, extension, and education. These increase agricultural productivity, which in turn raises national income through a multiplier effect. The result is increased food availability, women's education, and safe water and sanitation – and, consequently, improved nutrition. Alternatively, investments may be made directly in rural health, water, and sanitation, which will improve the health of the rural population and allow more efficient utilization of existing food.

At the household level, the most effective way of improving nutrition is to direct interventions towards women.<sup>9</sup> One approach, which has been used quite successfully in a number of countries using Title II food aid, is to channel resources through maternal and child health programs. These resources can be monetized to pay not only for health care but also for nutritional education, functional literacy programs, family planning, improved access to safe water and sanitation, and direct income transfers. In addition, some of the aid can be channeled to participants directly in the form of food assistance. Finally, investment in women's education, especially at the secondary school level, has been shown to have important nutritional benefits (Smith and Haddad, 1998).

## WHAT WILL IT COST?

In order to estimate the cost of achieving the Food Summit target of reducing the number of undernourished to 400 million by the year 2015, empirically derived parameters were used to link the interventions discussed above to resulting declines in undernutrition. A number of scenarios were then costed for different combinations of these interventions to achieve the Food Summit target. It was assumed that these interventions are incrementally added to the baseline interventions assumed in the projections discussed earlier and that they are for the most part financed by the donors. The countries and sub-regions for which these calculations were made are China, Indonesia, Rest of East and Southeast Asia, Pakistan, India, Bangladesh, Rest of South Asia, Nigeria, Ethiopia, War-Torn Sub-Saharan Africa (minus Ethiopia), Least Developed SSA, Developing SSA, Latin America and the Caribbean, and Rest of the Developing World. Because of higher levels of per capita income and lower levels of undernutrition in Latin America and the Caribbean and in the Rest of the World, it was

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<sup>9</sup> There is extensive literature on the nutritional benefits of women's status, education, and control over resources within the household. See, for example,

assumed that interventions in these regions would be financed by the countries themselves rather than by the donors, and these costs do not appear in the totals. The sole exception to this is technical assistance for policy change, which was assumed to be financed by the donors. Details of these calculations are contained in Annex A.

### **Scenario 1: Equal Distribution**

The first scenario assumes that all four policy interventions-reducing war and civil strife, increasing democracy, opening trade and investment policy environment, and reducing barriers to food imports-are achieved through a combination of international pressure and incentive and technical assistance and training at the national level. For interventions at the sectoral and household levels, the same level of funding is spent for each undernourished person in each of these countries and sub-regions and the funds are distributed equally among the interventions. These are:

- construction of rural roads
- agricultural research and extension
- monetized food aid targeted via maternal and child health programs
- female education
- improved access to safe water

The results of this scenario are presented in Table 2. They show that the total cost of achieving the Food Summit target under this scenario is \$ 65 billion, with the largest amounts spent in Asia because most of the undernourished are concentrated there. Although this scenario may be equitable, it is not very efficient in achieving the target.

Table 3 shows the cost per person removed from the list of undernourished by country/region and type of intervention. These costs are derived by estimating both the cost of each intervention and its effectiveness in decreasing the number of undernourished.

Only minimal costs have been estimated for reducing war or civil strife. These comprise the costs of engaging conflicting parties in a sustained dialogue that results in resolution of the conflict. It is assumed that this will remain an important goal of U.S. foreign policy, but it is impossible to estimate any additional costs involved. Furthermore, it is assumed that other interventions cannot be carried out as long as there is a significant level of physical insecurity so that progress must be made in the war-torn countries if undernutrition is to be reduced.

**Table 2****IMPACT OF INTERVENTIONS ON UNDERNOURISHED (millions)****Scenario 1: Equal Distribution**

	East & South East Asia	South Asia	War torn SSA	LDC SSA	Developing SSA	Latin America	Rest of World	Total # million people	Total Cost
National Political Policy									
Reduce war	-4	-1	-14	0	0	0	-4	-24	513
Increase democracy	-3	-3	-1	0	-1	0	-1	-9	1710
National Economic Policy									
Open trade	-11	-19	-1	0	-1	0	-4	-37	1997
Reduce food tariffs	-5	-2	-2	-1	-2	0	-2	-15	
Sectoral Policy									
Rural roads	-9	-10	-6	-3	-1	0	0	-29	12221
Agricultural research	-13	-75	-8	-2	-4	0	0	-103	12221
Household Policy									
Targeted food aid	-17	-25	-3	0	-1	0	0	-46	12221
Female literacy	-31	-108	-14	-4	-6	0	0	-162	12221
Safe water	-7	-26	-2	0	-1	0	0	-36	12221
Own resources	0	0	0	0	0	-13	-39	-52	0
<b>Total Reduction in Undernourished</b>	<b>-100</b>	<b>-270</b>	<b>-52</b>	<b>-10</b>	<b>-17</b>	<b>-14</b>	<b>-50</b>	<b>-513</b>	
<b>Total Cost</b>	<b>Million \$</b>	<b>17795</b>	<b>33753</b>	7214	2199	3784	186	396	<b>65326</b>

**Table 3**

<b>COST EFFECTIVENESS OF INTERVENTIONS : REDUCTION IN UNDERNOURISHED (\$/Capita)</b>					
	<b>East and South East Asia</b>	<b>South Asia</b>	<b>Sub-Saharan Africa</b>	<b>Latin America</b>	<b>Rest of World</b>
<b>National Policy Initiatives</b>					
Political Stability	15	24	20	62	23
Democratization	169	91	453	800	301
Economic	43	33	110	81	22
<b>Sectoral Investments</b>					
Rural Roads	390	1162	249	344	94
Agricultural Research	262	75	312	1305	1656
<b>Household</b>					
Targeted Food Aid	571	347	961	1555	164
Female Education	114	49	130	439	133
Increase access to safe water	586	236	1021	2194	754

Of the interventions for which costs have been estimated directly, the least cost-effective for at least for some countries/sub-regions are (1) construction of rural roads and (2) investment in safe water delivery. It is recognized, however, that these have important interactive effects with other variables. For example, the success of agricultural research depends on at least a minimum level of road infrastructure. Furthermore, access to safe water, while not by itself a very important contributor to improved nutrition, interacts with increased food availability and women's education. These interactive effects are taken into account in the final scenario, which achieves a balance between the different interventions, but in a relatively cost-effective way.

Technical assistance in support of economic policy reform is very cost-effective in most countries where reform is still needed. It is assumed here that governments are already committed to reform so that the only costs are those associated with providing technical assistance. The same is true of democratization, except that its influence on undernutrition is much weaker than that of economic policy reform, which has an important effect on economic growth.

Agricultural research, extension, and education is quite cost effective in reducing undernutrition, especially in South Asia and most of sub-Saharan Africa. Targeted food aid is also relatively efficient in at least some countries. It is assumed in the analysis that this aid is monetized and used to pay for a range of activities channeled through maternal and child health care programs. The particular activities are not specified but presumably would include health care, nutritional education, functional literacy, family planning, improved access to safe water and sanitation, and agricultural extension to women. They could also include food assistance and direct income supplements. The critical assumption here is that the total level of assistance is sufficient to move at least one-half the poor above the poverty line, assuming a capital output ration of 3.0. That is investments can be undertaken that equal three times one-half the level of the poverty

gap, and these investments enable the beneficiaries to remain above the poverty line indefinitely.

Another intervention that is very cost effective is investment in woman's education, especially at the secondary school level. This has an important effect on the allocation of food within the household. It also helps to raise the level of household income, benefiting all members of the household.

## **Scenario 2: Least Cost Distribution**

In Scenario 2, shown in Table 4, assistance in the reduction of war, democratization, and economic policy reform was assumed to remain at the same level as in Scenario 1. This is because these reforms are considered essential to the success of reforms at the sectoral level. Only those reforms carried out at the household level can be presumed to be successful in the absence of physical security, a reasonable level of democratic governance, and an enabling economic environment.

At other levels, resources were reallocated in directions leading towards greater cost-effectiveness in achieving the Food Summit target. Investment in rural roads and in safe water were abandoned altogether, and resources were reallocated not only towards other interventions but also marginally towards South Asia to the detriment of most other regions. The result is a substantial reduction in the cost of achieving the target from \$65 billion to \$39 billion. However, a very large part of the nutritional gain comes from investments in agricultural research and female education in South Asia. The former may be less than totally realistic given the fact that yields are already at moderate levels. Nevertheless, there is still substantial room for yields to increase, and there may be even further potential for increases in labor productivity associated with mechanization as agriculture modernizes.<sup>10</sup> As far as women's education is concerned, this is certainly an area in South Asia where investment is likely to have a high payoff in reducing undernutrition.

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<sup>10</sup> It is sometimes asserted that there is little scope for further increases in agricultural production in South Asia because most of the opportunities for improvement have already been exploited on good land and the opportunities that exist on poorer land are much less. This is contradicted for India, however, by the relatively high returns found to use of high yielding varieties and other interventions in areas of so-called low potential (Hazell and Fan, 1998).

**Table 4****IMPACT OF INTERVENTIONS ON UNDERNOURISHED (millions)****Scenario 2: Least cost distribution**

	<b>East &amp; South East Asia</b>	<b>South Asia</b>	<b>War torn SSA</b>	<b>LDC SSA</b>	<b>Developing SSA</b>	<b>Latin America</b>	<b>Rest of World</b>	<b>Total # million people</b>	<b>Total Cost</b>
National Political Policy									
Reduce war	-4	-1	-14	0	0	0	-4	-24	513
Increase democracy	-3	-3	-1	0	-1	0	-1	-9	1710
National Economic Policy									
Open trade	-11	-19	-1	0	-1	0	-4	-37	1997
Reduce food tariffs	-5	-2	-2	-1	-2	0	-2	-15	
Sectoral Policy									
Rural roads	0	0	0	0	0	0	0	0	0
Agricultural research	-13	-145	-3	-1	-3	0	0	-164	19079
Household Policy									
Targeted transfers	-42	-19	-1	0	0	0	0	-61	8342
Female literacy	0	-133	-13	0	-5	0	0	-150	7712
Safe water	0	0	0	0	0	0	0	0	0
Own resources	0	0	0	0	0	-13	-39	-52	0
<b>Total Reduction in Undernourished</b>	<b>-77</b>	<b>-322</b>	<b>-35</b>	<b>-2</b>	<b>-11</b>	<b>-14</b>	<b>-50</b>	<b>-513</b>	
<b>Total Cost</b>	<b>Million \$</b>	<b>10067</b>	<b>24707</b>	2401	392	1205	186	396	<b>39353</b>

At other level, resources were reallocated in directions leading towards greater cost-effectiveness in achieving the Food Summit target. Investment in rural roads and in safe water were abandoned altogether, and resources were reallocated not only towards other interventions but also marginally towards South Asia to the detriment of most other regions. The result is a substantial reduction in the cost of achieving the target from \$65 billion to \$39 billion. However, a very large part of the nutritional gain comes from investments in agricultural research and female education in South Asia. The former may less than totally realistic given the fact that yields are already at moderate levels. Nevertheless, there is still substantial room for yields to increase, and there may be even further potential for increases in labor productivity associated with mechanization as agriculture modernizes.<sup>11</sup> As far as women's education is concerned, this is certainly an area in South Asia where investment is likely to have a high payoff in reducing undernutrition.

### **Scenario 3: Efficiency with equity**

Whatever the efficiency of Scenario 2, it is clear that it leaves much to be desired in terms of equity, especially the extent to which Sub-Saharan Africa is excluded from major gains. Consequently, a third scenario was developed in which Sub-Saharan Africa is stressed to a much greater extent. This scenario is presented in Table 5. Heavy emphasis is placed especially on war-torn SSA, where substantial gains in nutritional status are possible at only moderate cost. Interventions in SSA are also strongly oriented towards agricultural research and female education. The cost of this scenario is \$43 billion, which is not much higher than Scenario 2. Further shifts towards Africa could also be undertaken without raising costs too much further.<sup>12</sup>

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<sup>11</sup> It is sometimes asserted that there is little scope for further increases in agricultural production in South Asia because most of the opportunities for improvement have already been exploited on good land and the opportunities that exist on poorer land are much less. This is contradicted for India, however, by the relatively high returns found to use of high yielding varieties and other interventions in areas of so-called low potential (Hazell and Fan, 1998).

<sup>12</sup> If the goal were set of reducing the proportion of undernourished by an equal percentage across all countries until the aggregate target were met, then Scenario 3 would result in the following rates of success in achieving this goal: East and Southeast Asia 41%, South Asia 134%, War-Torn SSA 109%, Least Developed SSA 73%, Developing SSA 67%, LAC 100%, and Rest of World 100%. Of course LAC and Rest of World accomplish this using only their own resources.

**Table 5**

**IMPACT OF INTERVENTIONS ON UNDERNOURISHED (millions)**

**Scenario 3: Rational distribution**

	<b>East &amp; South East Asia</b>	<b>South Asia</b>	<b>War torn SSA</b>	<b>LDC SSA</b>	<b>Developing SSA</b>	<b>Latin America</b>	<b>Rest of World</b>	<b>Total # million people</b>	<b>Total Cost</b>	
<b>National Political Policy</b>										
Reduce war		-4	-1	-14	0	0	0	-4	-24	513
Increase democracy		-3	-3	-1	0	-1	0	-1	-9	1710
<b>National Economic Policy</b>										
Open trade		-11	-19	-1	0	-1	0	-4	-37	1997
Reduce food tariffs		-5	-2	-2	-1	-2	0	-2	-15	
<b>Sectoral Policy</b>										
Rural roads		0	0	-5	-2	0	0	0	-7	1172
Agricultural research		0	-137	-15	-4	-8	0	0	-162	18664
<b>Household Policy</b>										
Targeted food aid		-18	-25	-4	0	0	0	0	-47	8889
Female literacy		-10	-121	-12	-4	-5	0	0	-151	8505
Safe water		0	-8	0	0	0	0	0	-8	1885
Own resources		0	0	0	0	0	-13	-39	-52	0
<b>Total Reduction in Undernourished</b>		<b>-51</b>	<b>-316</b>	<b>-53</b>	<b>-11</b>	<b>-16</b>	<b>-14</b>	<b>-50</b>	<b>-512</b>	
<b>Total Cost</b>	<b>Million \$</b>	<b>4040</b>	<b>27826</b>	<b>6720</b>	<b>1748</b>	<b>2418</b>	<b>186</b>	<b>396</b>		<b>43335</b>

**Table 6**

**IMPACT OF INTERVENTIONS ON UNDERNOURISHED (millions)**

**Scenario 4: Policy absent**

	East & South East Asia	South Asia	War torn SSA	LDC SSA	Developing SSA	Latin America	Rest of World	Total # million people	Total Cost
Household Policy									
Targeted food aid	-83	-126	-20	0	0	0	0	-230	47243
Female literacy	-23	-146	-14	-5	-5	0	0	-192	11379
Safe water	-6	-30	-3	-1	-1	0	0	-40	13288
Own resources	0	0	0	0	0	-13	-39	-52	0
<b>Total Reduction in Undernourished</b>	<b>-135</b>	<b>-327</b>	<b>-55</b>	<b>-7</b>	<b>-10</b>	<b>-14</b>	<b>-50</b>	<b>-600</b>	
<b>Percent of Target</b>	<b>117% Total</b>	<b>100% Nonpolicy</b>							
<b>Total Cost</b>	<b>Million \$</b>	<b>12614</b>	<b>50752</b>	10121	726	951	186	396	<b>71911</b>

#### **Scenario 4: Policy absent**

The last Scenario, shown in Table 6, looks at what could be done if there were no progress in reducing war, democratization, or economic policy reform. Under these conditions, investment in roads or agricultural research would be relatively ineffective since conditions would not be ripe to benefit from these investments. Nevertheless, interventions could be attempted at the household level with respect to targeted food aid, female education, and access to safe water, though in the absence of physical security even these would be difficult to implement. As the table shows, however, this scenario, even if it worked in meeting the Food Summit target, would be quite expensive at \$72 billion.

### **U.S. COMPARATIVE ADVANTAGE**

The scenario analysis indicates that it should be possible to achieve the food summit target for a total of about \$45 billion, or \$3 billion per year spread out over a period of 15 years. This is about 5 percent of current levels of official development assistance – not an impossible sum if all donors are involved.

In considering how the United States could best contribute to the alleviation of undernutrition, it is important to bear in mind the types of interventions in which it has a comparative advantage. These relate to U.S. position in the world economy, its experience with different types of foreign assistance, and other underlying factors.

#### **Most Productive Farmers in the World**

For more than a century, the U.S. system of agricultural research, extension, and education has produced the most productive farmers in the world. This system has been led by the land grant universities and the U.S. Department of Agriculture. Seed companies, equipment dealers, and other input suppliers have also been an important vehicle for extension. Techniques of plant and animal breeding developed under the system have been transplanted to developing countries via the international agricultural research centers under the aegis of the Consultative Group on International Agricultural Research. The land grant universities have themselves assisted the developing nations to modernize their agricultural sectors.

Unfortunately, the funds devoted to international agriculture and rural development have decreased dramatically. For example, funding in FY 1986 was at a level of \$1.2 billion; by FY 1997, it had dropped to an estimated \$240 million (McPherson, 1998). This represents an enormous waste of one of our most precious assets that could be used to aid in the fight against world hunger: the knowledge that resides in the scientists, extension agents, educators, administrators, and others who have experience with agricultural development.

## **NGO Experience in Food Aid Delivery and Community Participation**

NGOs have a wealth of experience associated with the delivery of food aid and community participation in a variety of programs. Of particular relevance is the use of monetized food aid under Title II to fund the activities of maternal and child health care programs. The activities of these programs have been expanded to include nutritional education, functional literacy, family planning, investment in safe water and sanitation, and agricultural extension to women. In addition, food aid has been channeled via these programs to needy women, infants, and children. Finally, NGOs have participated in programs designed to build community participation in the forging of linkages with agricultural research in order to promote environmentally sustainable agricultural development.<sup>13</sup>

## **Leader in International Trade Negotiations**

Since the 1930s, the United States has been the leader in promoting free trade through international trade negotiations, culminating most recently in the Uruguay Round. Increasingly these have focused on agriculture and are scheduled to do so again in the next round. They are also very much concerned with intellectual property rights, including those involving bio-technology – a critical issue for agricultural development.

Although substantial progress has been achieved in defining acceptable policy interventions, tariff ceilings, and tariff implementation modalities, numerous loopholes still exist. Many developing countries maintain protective food import regimes. Although food exporters are committed to reducing direct support to agriculture, reducing or eliminating export subsidies, and shifting from price controls to direct farmer income support, they are still susceptible to pressures from the agricultural community when market prices begin to decline. Furthermore, reliability of food exports is made questionable when food can be the subject of economic sanctions. Thus there is much to be done in creating efficient and reliable world food markets, in which the U.S. will play a vital role.

## **Worldwide Strategic Interests**

Today the United States clearly has worldwide strategic interests that result in its being involved in every area of the globe. Whether these interests be commercial, financial, political, or humanitarian, the U.S. cannot escape its responsibilities. If anything, these seem to have increased since the ending of the Cold War. This involvement has important implications for food security in areas of actual and potential war and civil strife. In many instances, prevention of violence or assisting nations in recovering from violence as quickly as possible may be the least costly way of meeting U.S. objectives, including those linked to food security.

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<sup>13</sup> An example is the On-Farm Productivity Enhancement Program (Antoine and Byrnes, 1993)

## **Strong Private Sector**

One of the great sources of strength in the U.S. economy is its vibrant private sector. In recent years, this sector has been playing an expanded role in developing nations, involving direct and portfolio investment, technological transfer, exploitation of market opportunities, and managerial assistance. This role is increasingly being applied to agricultural production, processing, marketing, and trade. An enormous opportunity exists to apply the motivation and know-how of the private sector to the task of assuring food security in the developing world.

## **U.S. STRATEGY FOR MEETING THE FOOD SUMMIT TARGET**

Analysis of the cost-effectiveness of various interventions to assure food security plus analysis of the comparative advantage of the United States in undertaking these interventions to the strategy outlined in this section. This strategy distinguishes between actions to be undertaken at the global, national, sectoral, and household levels. It also distinguishes between those actions thought to be most effective in South Asia, where the major problems are income inequality, poor health conditions, and low status of women, and those thought to be more effective in Africa, where the problems are war and civil strife, low food availability, poverty related to low levels of average per capita income, low overall school enrollment, and lack of access to safe water and sanitation.

## **Global Interventions**

In its global negotiations, the United States should continue to press for free trade in food as well as in other goods and services. This should involve encouraging countries to open their borders to food imports as a means of lowering domestic prices, increasing real incomes of the poor, and increasing food availability from imports as well as domestic production. To do this, however, the U.S. will have to guarantee the reliability of food supply by eliminating commercial food shipments from the list of goods potentially subject to economic sanctions. At the same time, it should encourage the European Union to abandon the practice of effectively taxing its food exports when world market prices rise in order to maintain more stable prices within the Union.

It is also important that the United States press forward on the international front to establish rules regarding trade in bio-technology products and to guarantee secure intellectual property rights insofar as bio-technology is concerned. There is major concern in the United States that the European union and other countries will adopt policies regarding the importation and planting of bio-technology products that will adversely affect U.S. agricultural exports. At the same time, there have been problems related to the protection of property rights to bio-technology where production of seeds has taken place in developing countries. Given the enormous potential that exists for bio-technology to contribute to alleviating undernutrition, it is vital that an appropriate legal and institutional framework be put in place.

A third area for international cooperation is with respect to rational management of shared resources. An example of particular importance to the food security of coastal population is in the conservation and sustainable exploitation of ocean fisheries.

### **National Interventions**

The preceding analysis has demonstrated the effectiveness of interventions in reducing war and civil strife, promoting democratization, and encouraging economic policy reform not only in contributing directly to the alleviation of undernutrition but also in setting the stage for other interventions to be effective. The U.S. has been an effective advocate of peace, democracy, and economic reform for many years. The benefits from this advocacy can now be seen to include progress in meeting the Food Summit target. Consequently, it is important that the United States continue to press forward in this direction and that it consider this action to be one of the ways in which it is contributing to meeting the Food Summit target. In addition, the United States should increase its contribution to technical assistance and training in policy reform, for which its academic community is internationally recognized.

### **Sectoral Interventions**

Sectoral interventions include investment in rural infrastructure and agricultural research, extension, and education. Investment in rural infrastructure can best be left to the World Bank and other donors, given that the United States has very limited resources and no strong comparative advantage in this area. On the other hand, the U.S. has extensive experience in agricultural research and development, which is largely going to waste because of the precipitous decline in funding that has occurred in recent years. It is proposed, therefore, that an important area of concentration for the United States in meeting the Food Summit target be agricultural research, extension, and education. It is further proposed that most of this effort be concentrated on Sub-Saharan Africa, where the problem of food availability and rural income growth is likely to be severe for a number of countries, but that some attention also be devoted to Asia, where population density is high and increasing pressure on the land is an important problem. Furthermore, the institutional environment in which agricultural development can take place differs markedly between the two continents.

*Sub-Saharan Africa.* In most of Sub-Saharan Africa, there is a vast need for agricultural research, extension, and education. During the colonial period, most research was concentrated on cash crops for export, such as coffee, tea, cocoa, groundnuts, cotton, sisal, oil palm, and rubber. From independence, more research effort was devoted to food crops, often using seeds and other plant materials supplied by the international agricultural research centers (IARCs). However, the national agricultural research systems (NARS) soon began to experience severe financial difficulties, which not only decreased their effectiveness in conducting research but also resulted in their losing well qualified personnel. At the same time, funding for the IARCs also declined.

Even more discouraging was the ineffectiveness of the national extension systems, which were under-funded and discouraged by weak systems of incentives. This led to the creation of publicly owned regional development enterprises, usually financed by the donors, which were financially and administratively autonomous from the central government. These enterprises were the main conduit for the integrated rural development projects of the 1970s, which combined extension, credit, input delivery, processing, and even health care and functional literacy programs in the same package. This created an enormous financial and managerial burden, which most of these enterprises were unable to sustain after donor funding ceased. The result was the collapse of any effort at agricultural extension.

Yet there have been important success stories in African agricultural development. One has been the development and spread of hybrid maize varieties in Zimbabwe. Another has been the growth of rice production in the irrigated perimeter of the Office du Niger in Mali. Also successful have been the cotton schemes run by CMDT in southern Mali and Cargill in Tanzania. The major ingredients of success in these projects have been the importance of the private sector, a free market environment, a profitable cash crop, a viable technology available to be transferred and adopted, and a mechanism for linking farmers to the researchers.

In areas where cash crop opportunities are not as readily apparent, a different model may have to be used. One such model, which has achieved considerable success in Africa, is the On-Farm Productivity Enhancement Program (Antoine and Byrnes 1993).<sup>14</sup> This program uses NGOs to link farmers with researchers working on improved seeds and soil fertility. An important element is local community participation. Farmers work together to ascertain their needs, to decide what innovations they want to try, and to develop standards by which they can judge the success of these innovations.

It is clear that innovative approaches must be used to achieve success in programs involving agricultural research, extension, and education in Sub-Saharan Africa. Some possibilities that might be considered are as follows.

- Establishment of an endowment fund to finance a small grants for innovative projects involving agricultural research, extension, and education. This would help to meet the operating expenses of the NARS and to assure that valuable research is continued.
- Cooperative agreements with the U.S. land grant universities to enable them to train African agricultural scientists and extension experts and to support research, extension, and education in Africa.
- Additional resources for the African Food Security Initiative to assure that it can finance innovative approaches to food security involving production, processing, marketing, storage, and trade of staple foods.
- Financing of participatory extension programs involving NGOs, based on a model similar to that of the On Farm Productivity Enhancement program.

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<sup>14</sup> The program was implemented jointly by Winrock International Institute for Agricultural Development, the Center for PVO/University Collaboration in Development, Save the Children, and several other NGO partners.

- Establishment of public-private partnerships similar to the Chile Foundation for the purpose of facilitating the transfer of agricultural production and processing technology to Africa and linking it to public sector research.

**South Asia.** The major difference between Sub-Saharan Africa and South Asia insofar as agricultural research, extension, and education is concerned is that, in contrast to SSA, the institutions in South Asia are in place to conduct agricultural research and extend its results to the farming community. The major problem here, instead, is that there is so much pressure on the land that it is difficult for production to keep up with population growth despite the fact that agriculture is already reasonably productive. What is needed is a sustained research effort to shift the yield curve further, partly through traditional research and partly through research involving bio-technology. It is recommended, therefore, that an endowment fund to finance small research grants, similar to the one recommended for Africa, be established in Asia as well.

**Global Research on Bio-Technology.** The main danger with current bio-technology research, which is funded to a substantial degree by the private sector, is that it will focus on the problems of the industrial countries, where the largest payoffs can be expected. Thus there is substantial effort going into quality improvement, micro-nutrient fortification, and resistance to pests, which may not be the priorities of the developing world. It is recommended, therefore, that a grants program be established to assure that research in bio-technology is directed at least in part towards the problems of the developing nations.

### **Household Interventions**

Some of the most cost-effective interventions can be made at the level of the household. This is especially important in South Asia, where undernutrition is due less to low levels of food availability than to a combination of poverty, low status of women, and poor health conditions. The World Bank is today embarked on a major program to improve access to safe water and sanitation in developing countries. Thus the U.S. should probably focus, instead, on other actions. The following interventions at the household level could form part of the U.S. strategy to meet the Food Summit Target. Although these efforts would be concentrated in Asia, they could also be applied to Sub-Saharan Africa to a lesser degree.

**Targeted Food Aid.** A considerable amount of Title II food aid is currently channeled through maternal and child health care programs. Some of this aid is monetized and used to pay for the programs and some is consumed directly as food assistance by participating women and children. Monetization is usually carried out by the NGOs who administer the programs. Aside from health care and food assistance, the programs often include nutritional and functional literacy education, family planning, improved access to safe water and sanitation, and agricultural extension for participating women.

The strategy envisioned here would strongly support these programs. It would also emphasize their developmental nature. That is, rather than being seen as essentially a safety net, these programs would be oriented towards eliminating participants' dependence on them. This could involve increased monetization of the food aid and the extension of the use of these funds to include capital investments made by participants to generate future income. These investments might include the purchase of sewing machines and other equipment, the leasing of shops or other physical facilities, and working capital.

A second feature of the strategy envisioned here is to assure that the distribution of food via these programs does not disrupt normal marketing of food. It is important to move as much as possible from a dual system involving public sector or NGO distribution, on one hand, and private sector marketing, on the other. This dual system impedes development of the private market and creates opportunities for graft and corruption. Thus the goal should be to distribute entitlement to food not the food itself. This might be achieved through a food stamp program or, using modern information technology, a system of smart cards that could be used to purchase food at local shops.

The third innovation of the strategy consists of monetization of food aid by private grain companies rather than by the NGOs. The grain companies can do this much more efficiently by selling the food in bulk in third markets and turning the proceeds over to the NGOs to be used for their maternal and child health care programs. This allows the NGOs to concentrate on what they are good at doing and takes advantage of the experience of the grain companies in international trade. Proceeds of the sale in foreign currency would be converted to local currency through the exchange market, which is increasingly the more desirable, non-inflationary way of obtaining counterpart funds.

***Women's Education.*** One of the most effective ways of dealing with the problem of undernutrition is to increase the education, status, and control over resources of women within the household. This usually results in more food and health care being allocated to women and children, who are those most deprived. Education at the secondary school level has proven to be most effective. Thus the strategy calls for intervening in any way possible to increase the education and status of women. At one level, this could take the form of technical assistance in the revising of laws regarding inheritance, land tenure, property rights, labor, divorce, and other areas. At another, it could lead to programs to improve physical facilities for girls, to get more women involved in secondary school teaching, to assist in the payment of school fees, and other actions. In South Asia, there is a need for concerted action to offset the existing gender bias. In Sub-Saharan Africa, the problem is less one of gender bias and more that of insufficient resources to pay teachers and poor quality of education.

## CONCLUSIONS

The analysis in this report has shown that if no additional action is taken, world undernutrition will increase in absolute terms by the year 2015. Yet there is a unique opportunity at the turn of the millennium for U.S. to exercise global leadership in meeting the Food Summit target of reducing the number of undernourished by more than one-half of the projected level. The report has also demonstrated that there is a viable and affordable strategy that exists for achieving this goal. The annual cost to all donors would be no more than \$45 billion, or 5 percent of the current level of official development assistance. A particular strategy for the U.S. to pursue is elaborated, with concentration on South Asia and Sub-Saharan Africa. This strategy draws upon the combined experience of U.S. farmers, agribusiness, NGOs, universities, foundations, and the U.S. government.

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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 IMPACT 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.

Projected changes to the year 2015 for other variables of the IFPRI /IMPACT child undernutrition model were 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**

	Food availability (DES)	Access to safe water (%)	Female secondary enrollment rate (%)
East and Southeast Asia		18%	41%
South Asia		15%	82%
Sub-Saharan Africa		27%	49%
Latin America + 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 "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**

Underlying variables	Impact of Income on Underlying variables		Impact of Underlying Variables Child Undernutrition (%) <sup>b</sup>	
	Parameter	Elasticity	Parameter	Elasticity
% Access to Safe water <sup>a</sup>	0 000092	0 343	-0 085	-0 164
% Female Sec Ed <sup>a</sup>	0 000083	0 528	-0 168	-0 202
Food Avail (DES)	0 1414	0 124	-0 000081	-0 732

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

Notes

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 intervention on older children (between the ages of 5 and 15 years old) and the measured impact for children 0 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 close to four for most developing countries of the world<sup>2</sup>. Lastly, the cost of each intervention is assessed based upon unit cost data for quantifiable interventions.

### National Level Interventions

At the national level, four 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 undernutrition, all are also considered to be necessary components of a policy environment conducive to interventions.

<sup>2</sup> Cf. Sixth World Food Survey Table 8

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.

### *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 Assumptions* 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 allocation 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 allocation 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 improves over the interval between 1995 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 in 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 <sup>3</sup>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 growth, 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

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<sup>3</sup> Cf review of literature by Sebastian Edwards, 1993, "Openness, Trade Liberalization and Growth in Developing Countries," *Journal of Economic Literature*, 31 1358-1393, and more recent research by Stryker and Pandolfi (1997), Sachs and Warner, 1996, "Sources of Slow Growth in African Economies," HIID Development Discussion Paper No 545

<sup>4</sup> Stryker and Pandolfi (1997), Sachs and Warner (1996)

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<sup>4</sup>. 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 regional 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 were 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 countries/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 derives from comparisons of estimates used in a variety of sources<sup>5</sup>.

### *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 operation 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<sup>7</sup>. 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 policy 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.

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<sup>5</sup> Cf. Assumptions of ERS, International Agricultural Baseline Projections to 2005, May, 1997, USDA/ERS

<sup>6</sup> J. Strauss and D. Thomas, Ch34 Human Resources: Empirical Modeling of Household and Family Decisions, Handbook of Development Economics, Vol. 3A (Amsterdam: North Holland, 1995), pp. 1894-1895

<sup>7</sup> The cost of reforms is modeled by a function which 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.

## Sectoral Level Interventions

### *Intervention 5 Rural Roads*

*Logic* Rural road density has been shown to be among the most important contributors to productivity growth in 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.

The model traces only the most important of these links, the impact of rural road investment on agricultural labor productivity. This, in turn, is assumed to have a multiplicative effect on aggregate national income. Income growth is then assumed to 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.<sup>8</sup> Craig, Pardee and Rosebloom (1997) have measured the impact of rural roads on agricultural productivity from cross-country data for developing countries. Their data yields a road density elasticity of agricultural labor productivity of 0.9. In this analysis, this elasticity has been increased 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/sub-regions for rural road densities and for agricultural productivity, an intercept parameter was sub-estimated for a function relating the two series.

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<sup>8</sup> 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.

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<sup>10</sup>. 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.

Rural road construction costs were obtained from the World Bank for construction of rural roads<sup>11</sup>. 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 savannah zones sufficient to accommodate 10 to 40 vehicles 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 agricultural productivity, which then has a multiplicative effect on national GDP. Per/capita income growth then affects the underlying causes of undernutrition.

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

<sup>9</sup> This technique evaluates the intercept  $b_0$  as follows

$$b_0 = 1/n \sum [\ln(A) - b_1 \ln(R)]$$

where  $n$  is the number of observations in the series,  $A$  is the agricultural product per capita rural labor,  $R$  is rural road density and  $b_1$  is the known partial elasticity relating the two. Obviously, the equation assumes that  $b_1$  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  $A$ .

<sup>10</sup> See Dunstan Spencer, 1994, and also Block and Timmer, 1994.

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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).<sup>2</sup> 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.

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 6 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 insecurity. 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 NGOs 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 from 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.<sup>13</sup>

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 (0.6) 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 7 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 \$52/female /year in Sub-Saharan Africa and \$35/female/year in Asia and the rest of the world. These data are taken from Summers, 1994.

## *Intervention 8 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<sup>10</sup>.

### **Limitations**

As is indicated by the discussion above, the analysis of interventions is only able to capture rough orders of magnitude of impact of each intervention on undernutrition. Weaknesses in the model reflect lack of empirical measurements of relationships and insufficient data, and structural simplifications in the model. Some of these are identified below in order to provide guidance for research to improve the analysis.

Insufficient empirical evidence/data

- The numbers of current and projected undernourished above 4 years of age as determined by anthropometric measurements
- The effects of specific interventions on undernourished people above 4 years of age
- Evidence of other pathways through which interventions affect undernutrition
- Evidence of interactions among different interventions which either increase or reduce their effectiveness in achieving the objective
- More specificity for countries and region specific with respect to parameters of impact for each intervention and with respect to intervention costs

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<sup>14</sup> For safe water, as with female education, the model includes an override such that investments in improving safe water cannot exceed the number of people who lack safe water.

Structural deficiencies in the model include

- Lack of inter-temporal analysis of flow of investment and of impact for each intervention
- Need for inclusion of interactions between different interventions
- Need to incorporate declining marginal impacts, absorptive capacity constraints, preconditions and other constraints to effectiveness for each intervention

Despite these limitations, the model does provide a rough assessment of the relative impact of alternative interventions to address chronic undernutrition. Absolute numbers are only indicative of orders of magnitude. This assessment can provide guidance for developing a general strategy to address undernutrition. The model also provides a framework for further research and identifies important lacunae in current understanding of the cost effectiveness of alternative interventions to reduce undernutrition.

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Annex A Appendix TableA. 1

NATIONAL LEVEL FOOD SECURITY STRATEGY INTERVENTIONS																	
		East & SE Asia			South Asia				Sub Saharan Africa					Latin America	Rest of World	Total	
		China	Indonesia	Other E,SE Asia	Pakistan	Bangladesh	India	Other South Asia	Nigeria	Ethiopia	Other War torn SSA	Other LDC SSA	Other Developing S S Africa				
<b>Political Reforms</b>																	
<b>a</b>	<b>Increase Political stability</b>	Target	0 0 Establish peace (drop indicator to 0)														
	Current Indicator	War torn	0 00	0 00	0 25	0 00	0 00	0 00	0 46	0 00	1 00	1 00	0 00	0 00	0 11	0 46	
	<b>Impact on All Undernourished</b>	change in prevalence (% points)	0 0%	0 0%	6 0%	0 0%	0 0%	0 0%	10 1%	0 0%	15 2%	16 7%	0 0%	0 0%	-2 1%	8 8%	
		Millions	0 00	0 00	3 73	0 00	0 00	0 00	1 46	0 00	-3 81	10 58	0 00	0 00	0 45	-4 43	-24 46
	<b>Impact on Undernourished Children</b>	change in prevalence (% points)	0 0%	0 0%	2 0%	0 0%	0 0%	3 7%	0 0%	8 0%	-8 0%	0 0%	0 0%	-0 9%	-3 7%		
		Millions	0 00	0 00	0 17	0 00	0 00	0 00	0 09	0 00	-0 64	1 62	0 00	0 00	-0 06	-0 51	-3 09
<b>b</b>	<b>Promote Democracy</b>	Target	30% reduction in difference between actual and optimal level														
	Indicator 85/89	Democracy index	0 80	1 70	4 59	3 10	2 50	4 50	2 48	1 40	1 50	0 88	1 03	2 09	4 30	2 13	
	Change in democratization index	INDEX PONTs	1 86	1 59	0 72	1 17	1 35	0 75	1 36	1 68	1 65	1 83	1 79	1 47	0 81	1 46	
	Impact on access to safe water	change in % with access to safe water	7%	6%	3%	4%	5%	3%	5%	6%	6%	6%	6%	5%	3%	5%	
	<b>Impact on All Undernourished</b>	change in prevalence (% points)	-1 7%	1 4%	0 7%	0 9%	1 1%	0 6%	1 1%	1 2%	0 9%	1 1%	-1 2%	-1 0%	-0 6%	-1 0%	
		Millions	2 1	0 6	0 4	0 4	0 6	2 1	0 2	0 4	0 2	0 7	-0 3	0 1	0 1	0 5	-8 8
	<b>Impact on Undernourished Children</b>	change in % undernourished	1%	0%	0%	0%	0%	0%	0%	0%	0%	1%	-1%	0%	0%	0%	
		Millions	0 1	0 0	0 0	0 0	0 0	-0 1	0 0	0 0	0 0	-0 1	0 0	0 0	0 0	0 1	-0 7
<b>Economic Reforms</b>																	

c Economic openness		Target	1 Sachs/Warner index target to 1 by 2005														
	Indicators	S&W Openness	0 00	1 00	0 55	0 00	0 00	0 00	0 33	0 00	0 00	0 12	0 12	0 24	0 75	0 41	
	Indirect effect on income growth via trade	addition to rate of growth	0 0%	0 0%	0 0%	0 0%	0 0%	0 0%	0 0%	0 0%	0 0%	0 0%	0 0%	0 0%	0 0%	0 0%	0 0%
	Direct effect on incomes via growth	addition to rate of growth	2 0%	0 00%	0 89%	2 00%	2 00%	2 00%	1 33%	2 00%	2 00%	1 76%	1 77%	1 52%	0 50%	1 19%	
	Compounded impact on percapita income	% change over 2005-2015	34 6 %	0 0%	14 3%	34 6%	34 6%	34 6%	22 0%	34 6%	34 6%	29 9%	30 0%	25 3%	7 8%	19 3%	
	Impact on All Undernourished	change in prevalence (% points)	5 2%	0 0%	-7 0%	-4 1%	-4 7%	-4 0%	-4 0%	2 6%	0 7%	-1 6%	-1 5%	-4 2%	-2 0%	-7 8%	
		Millions	6 4	0 0	-4 4	-1 8	2 7	13 6	-0 6	0 9	0 2	-1 0	0 4	0 5	0 4	3 9	36 59
	Impact on Undernourished Children	change in % undernourished	1 7%	0 0%	2 3%	-1 6%	-1 7%	-1 4%	1 5%	-1 1%	0 4%	-0 8%	-0 7%	1 8%	0 8%	3 2%	
		Millions	0 3	0 0	0 2	0 2	0 2	0 8	0 0	-0 1	0 0	-0 2	0 0	0 0	0 1	0 5	-2 48
d Reduce food import tariffs		Target	10% Maximum tariff														
	Indicator	Current food staple NPC	107%	167%	194%	101%	149%	108%	190%	320%	159%	180%	211%	125%	133%	182%	
	Domestic price effect of meeting target	% change in domestic price	0%	34%	-43%	0%	-26%	0%	42%	66%	31%	-39%	-48%	-12%	17%	40%	
	Impact on food availability	% change in DES	0%	7%	9%	0%	5%	0%	8%	13%	6%	8%	10%	2%	3%	8%	
	Impact on All Undernourished	change in prevalence (% points)	0 0%	-4 3%	-5 4%	0 0%	2 3%	0 0%	-4 1%	5 2%	-1 5%	-2 5%	-3 9%	1 0%	-1 7%	-4 4%	
		Millions	0 0	2 0	3 4	0 0	1 3	0 0	0 6	1 8	0 4	-1 6	-1 0	0 1	0 3	2 2	-14 74
	Impact on Undernourished children	change in prevalence (% points)	0 0%	1 5%	1 8%	0 0%	0 8%	0 0%	1 5%	2 2%	0 8%	-1 2%	-1 7%	0 5%	0 7%	1 8%	
		Millions	0 00	0 11	0 15	0 00	-0 09	0 00	-0 04	0 17	-0 06	0 24	-0 12	-0 01	0 04	-0 26	1 30
Note		Regional indicators are population weighted averages for countries in each region for which data exists															

Annex A Appendix Table A 2

SECTORAL FOOD SECURITY STRATEGY INTERVENTIONS																	
		East & SE Asia			South Asia				Sub Saharan Africa					Latin America	Rest of World	Total	
		China	Indonesia	Other E,SE Asia	Pakistan	Bangladesh	India	Other South Asia	Nigeria	Ethiopia	Other War torn SSA	Other LDC SSA	Other Developing S S Africa				
<b>II</b>	<b>SECTORAL</b>																
	Agricultural GDP/Capita	\$PPP 1985	444 00	677 00	677 00	642 00	789 00	623 00	800 00	800 00	255 21	623 50	544 60	1786 09	75 86	74 67	
	Rural Population	millions	836 57	126 98	200 41	84 90	97 85	680 29	32 59	67 54	48 85	116 07	81 45	81 92	117 04	146 68	
	Agricultural Share of GDP	% points	20 25	17 16	20 28	25 49	30 25	29 08	20 28	39 45	56 74	20 28	50 00	20 28	16 49	15 27	<b>20 28</b>
<b>a</b>	<b>Investment in rural infrastructure</b>	Target	<b>\$9</b> per capita undernourished														
	Rural road density	(km/km <sup>2</sup> )	0 21	0 79	1 03	0 66	0 13	0 90	0 17	0 16	0 07	0 31	0 21	0 61	0 41	0 30	
	Current rural road resource on agricultural land	Rural roads (km)	191929	134946	46841	136869	12738	150107	12512	47104	6835	9628	4353	11670	23014	18025	
	Change in rural road density	% change	0%	0%	0%	0%	0%	0%	0%	0%	170%	304%	282%	47%	0%	0%	
	Impact on labor productivity	% change	0%	0%	0%	0%	0%	0%	0%	0%	22%	32%	31%	8%	0%	0%	
	Impact on Income	% change	0 0%	0 0%	0 0%	0 0%	0 0%	0 0%	0 0%	0 0%	24 9%	13 1%	30 8%	3 2%	0 0%	0 0%	
	Direct Impact on Food Availability	% change	0 0%	0 0%	0 0%	0 0%	0 0%	0 0%	0 0%	0 0%	11 0%	16 1%	15 4%	4 0%	0 0%	0 0%	
	Impact on All Undernourished	change in prevalence (% points)	<b>0 0%</b>	<b>0 0%</b>	<b>0 0%</b>	<b>0 0%</b>	<b>0 0%</b>	<b>0 0%</b>	<b>0 0%</b>	<b>0 0%</b>	<b>3 2%</b>	<b>5 9%</b>	<b>-7 7%</b>	<b>2 3%</b>	<b>0 0%</b>	<b>0 0%</b>	
		Millions	<b>0 00</b>	<b>0 00</b>	<b>0 00</b>	<b>0 00</b>	<b>0 00</b>	<b>0 00</b>	<b>0 00</b>	<b>0 00</b>	<b>0 81</b>	<b>3 72</b>	<b>-2 04</b>	<b>-0 27</b>	<b>0 00</b>	<b>0 00</b>	<b>6 84</b>
	Impact on Undernourished Children	change in prevalence (% points)	<b>0 00%</b>	<b>0 00%</b>	<b>0 00%</b>	<b>0 00%</b>	<b>0 00%</b>	<b>0 00%</b>	<b>0 00%</b>	<b>0 00%</b>	<b>-1 70%</b>	<b>2 82%</b>	<b>-3 47%</b>	<b>-0 99%</b>	<b>0 00%</b>	<b>0 00%</b>	
		Millions	<b>0 00</b>	<b>0 00</b>	<b>0 00</b>	<b>0 00</b>	<b>0 00</b>	<b>0 00</b>	<b>0 00</b>	<b>0 00</b>	<b>-0 14</b>	<b>0 57</b>	<b>-0 24</b>	<b>-0 03</b>	<b>0 00</b>	<b>0 00</b>	<b>1 0</b>
<b>b</b>	<b>Investment in agricultural</b>	Target	<b>\$31</b> per capita undernourished														

<b>research</b>																	
<i>Current investment in research for agriculture</i>	<i>\$ total million</i>	1075 18	243 76	1044 97	111 61	108 51	704 83	37 58	86 90	40 50	141 00	112 90	254 59	800 00	3000 00		
<i>Investment in ag Research/capita rural pop</i>	<i>\$ per capita rural pop</i>	1 29	1 92	5 21	1 31	1 11	1 04	1 15	1 29	0 83	1 21	1 39	3 11	6 84	20 45		
<i>Annual Change in agric research</i>	<i>% change</i>	0%	0%	0%	79%	106%	97%	79%	79%	126%	91%	48%	9%	0%	0%		
<i>Cumulative Increase in labor productivity</i>	<i>% change</i>	0 0%	0 0%	0 0%	80 6%	100 9%	94 5%	80 4%	81 0%	114 3%	90 1%	53 8%	12 2%	0 0%	0 0%		
<i>Impact on Income</i>	<i>% change</i>	0 0%	0 0%	0 0%	41 1%	61 1%	55 0%	32 6%	63 9%	129 7%	36 6%	53 8%	5 0%	0 0%	0 0%		
<i>Direct Impact on Food Availability</i>	<i>% change</i>	0 0%	0 0%	0 0%	40 3%	50 5%	47 2%	40 2%	40 5%	57 1%	45 1%	26 9%	6 1%	0 0%	0 0%		
<i>Impact on Undernourished</i>	<i>change in prevalence (% points)</i>	0 0%	0 0%	0 0%	-24 2%	30 3%	-31 2%	-25 6%	-21 0%	16 8%	-16 5%	-13 4%	-3 5%	0 0%	0 0%		
	<i>Millions</i>	0 0	0 0	0 0	10 5	17 2	105 2	3 7	7 1	-4 2	-10 4	-3 6	0 4	0 0	0 0		
<i>Impact on Undernourished Children</i>	<i>change in prevalence (% points)</i>	0 0%	0 0%	0 0%	9 6%	11 2%	-11 2%	-9 3%	-9 0%	-8 8%	-7 9%	6 1%	-1 5%	0 0%	0 0%		
	<i>Millions</i>	0 00	0 00	0 00	0 89	-1 16	6 01	-0 23	-0 69	-0 71	-1 59	-0 43	-0 04	0 00	0 00	11 75	

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Annex A Appendix Table A 3

HOUSEHOLD AND INTRA HOUSEHOLD FOOD SECURITY STRATEGY INTERVENTIONS																
		East & SE Asia			South Asia				Sub Saharan Africa					Latin America	Rest of World	Total
		China	Indonesia	Other E, SE Asia	Pakistan	Bangladesh	India	Other South Asia	Nigeria	Ethiopia	Other War torn SSA	Other LDC SSA	Other Developing SS Africa			
<b>a</b>	<b>Targeted Food AID</b>															
	<i>Poverty Gap</i>	<i>Daily cents per capita deficiency</i>	9 20	2 00	2 60	2 60	7 00	15 60	11 55	11 70	8 00	13 00	23 61	13 43	10 04	0 60
	<i>Income Transfer</i>	<i>\$/year/person</i>	770 6	76 5	170 0	90 2	144 8	408 6	343 9	457 0	259 3	578 5	1481 4	1663 2	1555 4	163 8
	<b>Impact on Undernourished</b>	<i>change in prevalence (% points)</i>	0 0%	24 2%	10 9%	20 5%	-12 8%	-2 3%	-5 4%	0 0%	-7 1%	-3 2%	0 0%	0 0%	0 0%	0 0%
		<i>Millions</i>	0 0	11 4	6 8	8 9	-7 2	-7 6	0 8	0 0	1 8	2 0	0 0	0 0	0 0	0 0
	<b>Impact on Undernourished Children</b>	<i>change in prevalence (% points)</i>	0 0%	24 2%	10 9%	-20 5%	-12 8%	-2 3%	-5 4%	0 0%	-7 1%	-3 2%	0 0%	0 0%	0 0%	0 0%
		<i>Millions</i>	0 00	-1 81	0 92	1 90	-1 32	1 21	-0 13	0 00	0 57	-0 65	0 00	0 00	0 00	0 00
<b>b</b>	<b>Empower Women</b>	<i>Target investment</i>	\$8 per capita undernourished													
	<i># Females 15-19</i>	<i>Millions</i>	46 1	10 3	14 5	6 4	6 1	43 8	1 9	6 2	2 8	8 5	6 1	7 4	20 9	15 4
	<i>Projected % Female Secondary enrollment 2015</i>	<i>%</i>	71%	64%	70%	84%	84%	11%	91%	63%	54%	54%	54%	69%	61%	63%
	<i>Annual additional females enrolled</i>	<i>millions</i>	3	1	1	1	1	32	0	2	1	3	2	1	0	0

	<b>Impact on Undernourished</b>	change in prevalence (% points)	3 2%	5 3%	5 2%	-5 5%	6 0%	34 1 %	3 4%	-12 2%	12 0%	-13 7%	-14 7%	3 2%	0 0%	0 0%	
		Millions	3 9	2 5	3 2	-2 4	3 4	-114 8	0 5	-4 2	3 0	-8 6	-3 9	0 4	0 0	0 0	150 8
	<b>Impact on Undernourished Children</b>	change in prevalence (% points)	-1 0%	1 8%	1 7%	-2 2%	2 2%	12 3 %	1 2%	5 2%	6 4%	6 5%	6 6%	-1 4%	0 0%	0 0%	
		Millions	0 17	0 14	0 15	0 20	0 23	6 57	0 03	0 40	0 51	1 32	-0 47	0 04	0 00	0 00	10 2
<b>c</b>	<b>Increase access to safe water</b>	Target expenditure	\$5 per capita undernourished														
	Projected Access to safe water 2015	% with Safe water	86%	69%	71%	66%	85%	68%	52%	58%	47%	55%	66%	74%	75%	78%	
	# of additional people w/access	Millions	0	0	0	0	17	104	4	0	0	0	0	0	0	0	
	<b>Impact on Undernourished</b>	change in prevalence (% points)	0 0%	0 0%	0 0%	0 0%	-2 5%	-2 0%	1 8%	0 0%	0 0%	0 0%	0 0%	0 0%	0 0%	0 0%	
		Millions	0 0	0 0	0 0	0 0	1 4	6 8	0 3	0 0	0 0	0 0	0 0	0 0	0 0	0 0	-8 5
	<b>Impact on Undernourished Children</b>	change in prevalence (% points)	0 0%	0 0%	0 0%	0 0%	-0 9%	-0 7%	0 7%	0 0%	0 0%	0 0%	0 0%	0 0%	0 0%	0 0%	
		Millions	0 000	0 000	0 000	0 000	0 095	0 390	0 016	0 000	0 000	0 000	0 000	0 000	0 000	0 000	0 5

Annex A Appendix Table A 4

		<i>China</i>	<i>Indonesia</i>	<i>Rest East SE Asia</i>	<i>Pakistan</i>	<i>Bangladesh</i>	<i>India</i>	<i>Rest South Asia</i>	<i>Nigeria</i>	<i>Ethiopia</i>	<i>War torn Africa</i>	<i>Peaceful LDC Africa</i>	<i>Rest SS Africa</i>	<i>Latin America</i>	<i>Rest of World</i>
<i>Dietary Energy Supply</i>	Kcal/capita	2710	2700	2549	2340	1990	2330	2185	2100	1620	1906	2243	2352	2500	2858
<i>% undernourished (FAO measure)</i>	% 1990/92	16	12	17	17	34	21	28	38	65	51	33	31	22	13
<i>Number of undernourished (FAO measure)</i>	Million, 1995	192	23	63	22	41	195	11	42	37	73	41	36	66	43
<i>% children undernourished (WHO measure)</i>	% 1990/95	21	38	28	40	67	53	46	35	40	31	25	18	11	15
<i>Number undernourished children (WHO measure)</i>	Million 0 5 yrs, 1995	22	8	9	9	10	59	2	7	5	9	5	5	6	6
<i>Population 1995</i>	millions	1200	193	358	130	120	929	40	111	56	158	113	138	461	342
<i>Income per capita</i>	\$ 1985	1493	2102	4867	1432	1510	1264	2014	978	312	762	666	2184	3281	5033
<i>Poverty gap (\$/capita deficit of poor)</i>	\$ 1985	9	2	3	3	na	16	12	12	8	13	24	13	10	1
<i>Female Illiteracy rate</i>	%	27	22	19	76	74	62	52	53	75	64	63	40	16	44
<i>Female primary school enrollment rate</i>	%	116	112	92	49	105	91	99	82	19	56	61	100	97	84
<i>Access to safe water</i>	%	83	63	64	60	83	63	48	43	27	39	52	65	76	75
<i>Access to sanitation</i>	%		55	69	30	30	29	26	63	10	28	36	56	67	62
<i>Smallholder farmers</i>			281349		13486	60167	75626			30606					
<i>Landless</i>			179584		23799	19010	19227			6278					
<i>Nomadic pastoralist</i>			0		1904	0	0			na					
<i>Small fishermen</i>			7782		873	6112	16791			na			3		
<i>Refugees</i>			247		3955	0	2			701			14.7%		
<i>Households headed by women</i>			89790		6902	15280	25636			21581					
<i>Population, 2015</i>	millions	1395	247	495	206	161	1208	58	182	112	346	245	237	616	515

		<i>China</i>	<i>Indonesia</i>	<i>Rest East SE Asia</i>	<i>Pakistan</i>	<i>Bangladesh</i>	<i>India</i>	<i>Rest South Asia</i>	<i>Nigeria</i>	<i>Ethiopia</i>	<i>War torn Africa</i>	<i>Peaceful LDC Africa</i>	<i>Rest SS Africa</i>	<i>Latin America</i>	<i>Rest of World</i>
<i>Income/cap of poorest</i>	\$ 1985	90	193	384	117	141	113	136	39	20	49	32	126	149	171
<i>Share of income to poorest</i>	% of average	6.0%	9.2%	7.9%	8.2%	9.4%	8.9%	6.7%	4.0%	6.4%	6.4%	4.9%	5.8%	4.5%	3.4%
<i>Openness</i>		0.00	1.00	0.45	0.00	0.00	0.00	0.33	0.00	0.00	0.08	0.23	0.28	0.70	0.53
<i>Ratio life expectancy women to men</i>		1.05	1.06	1.07	1.03	1.03	1.02	1.04	1.05	1.07	1.06	1.05	1.06	1.08	1.04
<i>Rural road density to ag Land</i>	(km/km <sup>2</sup> )	0.21	0.79	4.75	0.66	0.13	0.90	0.17	0.16	0.07	0.27	0.28	0.54	0.95	0.36

ANNEX A Appendix Table 5  
 COST EFFECTIVENESS OF INTERVENTION REDUCTION IN UNDERNOURISHED (\$/Capita)

	<i>China</i>	<i>Indonesia</i>	<i>Other E,SE Asia</i>	<i>Pakistan</i>	<i>Bangladesh</i>	<i>India</i>	<i>Other South Asia</i>	<i>Nigeria</i>	<i>Ethiopia</i>	<i>Other War torn SSA</i>	<i>Other LDC SSA</i>	<i>Other Developing S S Africa</i>	<i>Latin America</i>	<i>Rest of World</i>
<b>National Policy Initiatives</b>														
<i>Political Stability</i>	na	na	15	na	na	na	24	na	28	18	na	na	62	23
<i>Democratization</i>	161	185	189	210	132	59	305	272	355	225	427	920	800	301
<i>Economic</i>	59	0	13	80	32	26	43	51	191	63	98	191		22
<b>Sectoral Investments</b>														
<i>Rural Roads</i>	403	749	151	1058	81	1355	277	544	199	94	73	356	344	94
<i>Agric Research</i>	249	150	365	96	72	71	91	111	124	137	190	848	1305	1656
<b>Household</b>														
<i>Targeted Transfers</i>	771	77	170	90	145	409	344	457	259	578	1481	1663	1555	164
<i>Female Education</i>	130	79	80	61	42	49	49	82	62	67	107	289	439	133
<i>Increase access to safe water</i>	665	322	464	333	186	228	257	540	553	619	985	2088	2194	754

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**ANNEX A Appendix Table A 6**  
**INTERVENTION COSTS BY INTERVENTION AND COUNTRY/REGION**  
**SCENARIO 4 RATIONAL DISTRIBUTION**  
**( Million \$ US, 1998)**

(Millions \$US, 1995)	East & SE Asia			South Asia				Sub-Saharan Africa					Latin America	Rest of World	Total
	China	Indonesia	Other E,SE Asia	Pakistan	Bangladesh	India	Other South Asia	Nigeria	Ethiopia	Other War torn SSA	Other LDC SSA	Other Develo ping S S Africa			
<i>Policy costs Pol Stability</i>	0	0	55	0	0	0	35	0	106	186	0	0	28	104	<b>513</b>
<i>Policy costs Democrat</i>	331	119	77	80	81	124	49	108	83	163	133	108	96	158	<b>1,710</b>
<i>Policy costs Trade/Macro</i>	373	0	99	143	127	348	51	135	106	164	138	117	62	135	<b>1,997</b>
<i>Rural roads</i>	0	0	0	0	0	0	0	0	232	585	246	109			<b>1,172</b>
<i>Agric Research</i>	0	0	0	1 321	1 728	10,269	444	1,035	766	1,930	811	360			<b>18,664</b>
<i>Targeted AID</i>	0	873	1 153	801	1,048	3,112	269	0	464	1,169	0	0			<b>8,889</b>
<i>Female Education</i>	505	196	259	144	141	5,601	24	339	188	579	420	108			<b>8,505</b>
<i>Safe water</i>	0	0	0	0	262	1 556	67	0	0	0	0	0			<b>1,885</b>
<b>Total Cost</b>	<b>1 209</b>	<b>1,188</b>	<b>1,644</b>	<b>2 490</b>	<b>3 387</b>	<b>21,010</b>	<b>939</b>	<b>1,617</b>	<b>1 945</b>	<b>4,775</b>	<b>1 748</b>	<b>801</b>	<b>186</b>	<b>396</b>	<b>43,335</b>

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Annex A Appendix Table A 7

## Analysis of Variables Affecting Percentage of Children Nourished

	I		II		III		IV		V		VI	
	Coeff	Std Err										
C	-22 3471	7 4944	-50 1617	21 7052	-10 2309	79 2236	-13 0541	77 6590	3 2068	74 6698	-53 2342	19 8015
ESEA	-15 3930 ***	4 1479	-16 7349 ***	4 2067	-16 8116 ***	4 2628	-17 5729 ***	3 6627	-17 2041 ***	3 6151	-17 5043 ***	3 6167
SA	-20 3428 ***	3 8967	-22 9880 ***	4 3046	-23 3808 ***	4 4232	-24 1148 ***	3 8813	-25 0075 ***	3 7049	-23 7281 ***	3 7679
LDES					-6 0615	11 5540	-6 0942	11 3797	-10 0906	10 2257		
LGDPGAP			4 2246	3 0998	5 1086	3 5628	5 8090 *	2 9578	7 3829 ***	2 2373	4 9281 *	2 4288
URB	0 1128	0 0757	0 0351	0 0939	0 0348	0 0951						
WAR	-9 2498 **	3 9302	-7 7788 *	4 0227	-8 2403 *	4 1678	-8 5082 **	4 0411	-8 2392 **	4 0056	-8 0472 **	3 9011
ILLW	-0 0977	0 0597	-0 0684	0 0627	-0 0529	0 0701	-0 0561	0 0685			-0 0718	0 0611
SAN	0 1257 **	0 0596	0 0988	0 0620	0 1041	0 0636	0 1001	0 0618	0 1161 *	0 0583	0 0948	0 0602
POVGAP	-0 2863 **	0 1147	-0 2272 *	0 1211	-0 2387 *	0 1246	-0 2419 *	0 1224	-0 2215 *	0 1192	-0 2303 *	0 1191
Adj R-sq	0 77		0 78		0 78		0 78		0 78		0 79	
N	38		38		38		38		38		38	

Note

Variables C = constant

- ESEA = East and South East Asia  
 SA = South Asia  
 LDES = log of Dietary Energy Supply (Kcal per capita , annual, 1992, FAO)  
 LGDPGAP = Log of Income per capita, (\$ PPP) Penn tables  
 URB = % Urbanization of population  
 WAR = whether there has been protracted conditions of war since 1985  
 ILLW = female illiteracy rate  
 SAN = Percent of population with access to sanitation  
 POVGAP = Poverty gap (Cents/day /person)

Annex A Appendix Table A.8  
COUNTRY SAMPLE AND CATEGORIZATION BY REGION

Country	Regions	South east Asia	South Asia	Wartorn Africa	LDC Africa	Developing Africa	Latin America	Rest of World
Afghanistan	4	0	0	0	0	0	0	0
Algeria	6	0	0	0	0	0	0	0
Angola	1	0	0	1	0	0	0	0
Argentina	5	0	0	0	0	0	1	0
Bangladesh	2	0	0	0	0	0	0	1
Benin	1	0	0	0	1	0	0	0
Bolivia	5	0	0	0	0	0	1	0
Botswana	1	0	0	0	0	1	0	0
Brazil	5	0	0	0	0	0	1	0
Burkina Faso	1	0	0	0	1	0	0	0
Burundi	1	0	0	1	0	0	0	0
Cambodia	3	1	0	0	0	0	0	0
Cameroon	1	0	0	0	0	1	0	0
Central African Republic	1	0	0	1	0	0	0	0
Chad	1	0	0	1	0	0	0	0
Chile	5	0	0	0	0	0	1	0
China	3	0	0	0	0	0	0	1
Colombia	5	0	0	0	0	0	1	0
Congo Rep	1	0	0	1	0	0	0	0
Costa Rica	5	0	0	0	0	0	1	0
Cote d'Ivoire	1	0	0	0	0	1	0	0
Cuba	5	0	0	0	0	0	1	0

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Annex A Appendix Table A.8 cont

Country	Regions	South east Asia	South Asia	Wartorn Africa	LDC Africa	Develop- ing Africa	Latin America	Rest of World
Dominican Republic	5	0	0	0	0	0	1	0
Egypt, Arab Rep	6	0	0	0	0	0	0	0
El Salvador	5	0	0	0	0	0	1	0
Ethiopia	0 5	0	0	0	0	0	0	0
Gabon	1	0	0	0	0	1	0	0
Gambia, The	1	0	0	0	1	0	0	0
Ghana	1	0	0	0	0	1	0	0
Guatemala	5	0	0	0	0	0	1	0
Guinea	1	0	0	0	1	0	0	0
Guyana	5	0	0	0	0	0	1	0
Haiti	5	0	0	0	0	0	1	0
Honduras	5	0	0	0	0	0	1	0
Hong Kong	3	1	0	0	0	0	0	0
India	2	0	0	0	0	0	0	1
Indonesia	3	0	0	0	0	0	0	1
Iran, Islamic Rep	6	0	0	0	0	0	0	0
Iraq	6	0	0	0	0	0	0	0
Jamaica	5	0	0	0	0	0	1	0
Jordan	6	0	0	0	0	0	0	0
Kenya	1	0	0	0	0	1	0	0
Korea Dem Rep	2	1	0	0	0	0	0	0
Korea Rep	2	1	0	0	0	0	0	0
Kuwait	6	0	0	0	0	0	0	0
Lao PDR	3	1	0	0	0	0	0	0
Lebanon	6	0	0	0	0	0	0	0
Lesotho	1	0	0	0	1	0	0	0
Liberia	1	0	0	1	0	0	0	0
Libya	6	0	0	0	0	0	0	0
Madagascar	1	0	0	0	1	0	0	0
Malawi	1	0	0	0	1	0	0	0
Malaysia	3	1	0	0	0	0	0	0
Mali	1	0	0	0	1	0	0	0
Mauritania	1	0	0	0	1	0	0	0
Mauritius	1	0	0	0	0	1	0	0
Mexico	5	0	0	0	0	0	1	0
Mongolia	2	1	0	0	0	0	0	0
Morocco	6	0	0	0	0	0	0	0
Mozambique	1	0	0	1	0	0	0	0
Myanmar	3	1	0	0	0	0	0	0

Namibia	1	0	0	0	0	1	0	0
Nepal	2	0	1	0	0	0	0	0
Nicaragua	5	0	0	0	0	0	1	0
Niger	1	0	0	0	1	0	0	0
Nigeria	0 5	0	0	0	0	0	0	0
Pakistan	2	0	0	0	0	0	0	1
Panama	5	0	0	0	0	0	1	0
Paraguay	5	0	0	0	0	0	1	0
Peru	5	0	0	0	0	0	1	0
Philippines	3	1	0	0	0	0	0	0
Rwanda	1	0	0	1	0	0	0	0
Saudi Arabia	6	0	0	0	0	0	0	0
Senegal	1	0	0	0	0	1	0	0
Sierra Leone	1	0	0	1	0	0	0	0

Annex A Appendix Table A.7 cont.

Country	Regions	South east Asia	South Asia	Wartorn Africa	LDC Africa	Developi ng Africa	Latin America	Rest of World
Somalia	1	0	0	1	0	0	0	0
South Africa	1	0	0	0	0	1	0	0
Sri Lanka	2	0	1	0	0	0	0	0
Sudan	1	0	0	1	0	0	0	0
Suriname	5	0	0	0	0	0		0
Swaziland	1	0	0	0	0	1	0	0
Tanzania	1	0	0	0	1	0	0	0
Thailand	3	1	0	0	0	0	0	0
Togo	1	0	0	0	1	0	0	0
Trinidad and Tobago	5	0	0	0	0	0	1	0
Tunisia	6	0	0	0	0	0	0	0
Turkey	6	0	0	0	0	0	0	0
Uganda	1	0	0	1	0	0	0	0
United Arab Emirates	6	0	0	0	0	0	0	0
Uruguay	5	0	0	0	0	0	1	0
Venezuela	5	0	0	0	0	0	1	0
Vietnam	3	1	0	0	0	0	0	0
Yemen, Rep	6	0	0	0	0	0	0	0
Zaire	1	0	0	1	0	0	0	0
Zambia	1	0	0	0	1	0	0	0
Zimbabwe		0	0	0	0	1	0	0

## Model Organization

The model contains five principal sheets

*Parameters* contains the parameters which determine the relationships between various independent variables and undernutrition. This sheet presents a variety of parameters but only those boxed in blue are used by the model.

*Regional* presents summary data by country and region that the analysis focuses on. These include current and projected levels of undernutrition as well as summary characteristics of underlying variables that influence levels of undernutrition.

*Main data* Contains data by country used by the model. Other worksheets (Impact and Regions) use database commands to extract data from this base for the analysis.

*Impact* is the core of the model and presents the analysis of the nine interventions identified above.

*Results* contains a table at the top linked to the Impact sheet which summarizes the results of a particular scenario. The values of the results can be copied from this table to other space to save the results of a particular scenario before changing the scenario.

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<sup>1</sup> Publications with a reference number are available from USAID Publications with no reference number are available from Abt Associates All reports are in English except those marked Sp (Spanish) and Fr (French)

<sup>2</sup> APAP's report numbering system designates different types of reports Technical reports begin with the digit one or two core and collaborative research reports begin with three methods and guidelines reports begin with four handbook reports begin with five

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