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A Global Hunger Index: Measurement Concept, Ranking of Countries, and Trends

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Abstract

Progress in combating hunger and undernutrition has been lagging for decades. Best practices to fight hunger and undernutrition have been available for a long while, but lack of political will among leaders and a lack of political power among the poor have hampered their implementation. Since indices have proven to be powerful tools for advocacy and are able to capture multifaceted phenomena, the Global Hunger Index (GHI) was developed to increase attention to the hunger problem and mobilize the political will to speed up urgently needed progress in the fight against hunger. The GHI captures three dimensions of hunger: insufficient availability of food, shortfalls in the nutritional status of children, and child mortality, which is to a large extent attributable to undernutrition. Accordingly, the index includes three equally weighted indicators: the proportion of people who are food energy deficient as estimated by the Food and Agriculture Organization of the United Nations (FAO), the prevalence of underweight in children under the age of five as compiled by the World Health Organization (WHO), and the under-five mortality rate as reported by the United Nations Children's Fund (UNICEF). The GHI has been calculated for 1981, 1992, 1997, and, most recently, for 2003. The latest round ranks 97 developing countries and 22 countries in transition. Nine out of the 12 worst-ranking countries were engaged in wars between 1989 and 2003. The hot spots of hunger and undernutrition are in South Asia and Sub-Saharan Africa. While favorable trends prevailed in South Asia and Southeast Asia during the past two decades, progress has been sluggish in Sub-Saharan Africa. To identify those countries that do notably better or worse with regard to hunger and undernutrition than would be expected from their Gross National Income (GNI) per capita, a regression analysis of the GHI on GNI per capita is run. Controlling for the variation in GNI per capita, the GHI is 22 percent higher in war countries than in non-war countries, which is attributable to a higher proportion of people who are food energy deficient and a higher prevalence of underweight children. Likewise, in countries with an HIV prevalence greater than 10 percent, the GHI is 23 percent higher than in countries with lower prevalence rates, which can be traced back to a higher proportion of the population being food energy deficient and to a higher under-five mortality rate.

Key words: hunger, undernutrition, child malnutrition, child mortality, food availability, indicators, HIV/AIDS, conflict, war, developing countries, countries in transition

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1. Introduction

Background

The fight against hunger and undernutrition has long been an element of the development agenda. Food security and nutrition are pursued for their own sake, and are also key components of poverty reduction. In spite of this, progress in combating hunger and malnutrition has been lagging behind the targets aspired to for decades. And even if the Millennium Development Goal to halve the proportion of hungry people by 2015 was achieved, about 580 million people might continue to suffer from hunger in 2015 according to recent predictions (FAO 2006a). This means that the 1996 World Food Summit's aim to cut the number of hungry people to 410 million by 2015 would be missed by a great margin of 170 million people.[1] "Best practices" to combat hunger and undernutrition have been available for a long time, but lack of political will on the part of leaders and lack of political power among the poor has hampered their implementation (Heidhues and von Braun 2004).

Nongovernmental organizations like the Deutsche Welthungerhilfe (DWHH/GAA[2]) play an important role in supporting people in need by providing humanitarian and development assistance. They also engage in advocacy, lobbying for the powerless and giving the voiceless a voice[3] (DWHH 2006). Organizations such as

[1] The aim of the World Food Summit participants to halve the *number* of undernourished people is more ambitious than the Millennium Development Goal to cut the *proportion* of undernourished by half because the world's population is growing. Therefore, halving the *proportion* of undernourished by 2015 leads to a target number of about 580 million hungry people in 2015, whereas halving the *number* of undernourished people estimated for 1990-92 (the World Food Summit target baseline period) by 2015 results in a target number of about 410 million (FAO 2006a). It is important to distinguish between the proportion of undernourished in the total population and the absolute number of undernourished people: in Sub-Saharan Africa, the proportion of undernourished fell from 36 percent to 33 percent during the 1990s. Yet, while the total population grew from 477 to 620 million during the same period (an increase by about 30 percent), the number of hungry people on the subcontinent rose from 170 to 204 million (a less-than-proportionate increase by about 16 percent) (FAO 2005).

[2] German Agro Action, which is the English designation of Deutsche Welthungerhilfe.

[3] The potential of NGOs from the North to empower poor and disadvantaged groups in the South appears limited. However, they can make a contribution by raising awareness in their home countries with regard to hunger and poverty and by partnering with local NGOs in the developing world.

this have been called on to monitor and evaluate the implementation of the voluntary guidelines on the right to food recently adopted by 187 FAO member states; as such, it is their responsibility to publicly expose unfavorable trends. Where national governments lack willingness to act, civil society organizations can step in and hold the state accountable to its commitments (Windfuhr 2006; Cohen 2006).

Advocacy should be based on solid scientific evidence. However, measuring even the narrowest aspect of food insecurity—inadequacy of dietary energy intake, for instance—at regular and timely intervals is fraught with data and methodological challenges (FAO 2003; Smith, Alderman, and Aduayom 2006). The lack of a commonly accepted, comprehensive measure for food security on an international scale has been identified as one of the roadblocks on the way to the eradication of hunger and malnutrition (Heidhues and von Braun 2004).

Various international indices have been designed to measure other complex phenomena that cannot be captured adequately by a single indicator. Prominent examples that have been successfully employed for advocacy are the United Nations Development Program's Human Development Index and the Corruption Perceptions Index released by Transparency International (UNDP 2005; Transparency International 2006). An attempt was made by the Center for Development Research (ZEF) with an international Nutrition Index (Wiesmann et al. 2000) and by Bread for the World Institute to establish a "Hunger Index" in its 2001 Annual Report on the State of World Hunger (Berkman 2001). Yet, this approach was not followed in subsequent editions of the report (personal communication with Douglas Hicks, the author of the Hunger Index). Consequently, a widely propagated "hunger index" is still lacking. This study seeks to fill this gap by developing and applying a Global Hunger Index to measure hunger.

Objectives

The present study has the following three objectives:

1. Design a Global Hunger Index (GHI) as a tool for international monitoring and advocacy, and demonstrate its added value.
2. Rank countries according to the GHI and illustrate trends.
3. Interpret the GHI findings and analyze determinants of hunger.

The index should have a scientifically sound basis and be available for as many developing countries and countries in transition as possible. The underlying data should be released annually, so that updated rankings can be presented each year.

Organization of the Study

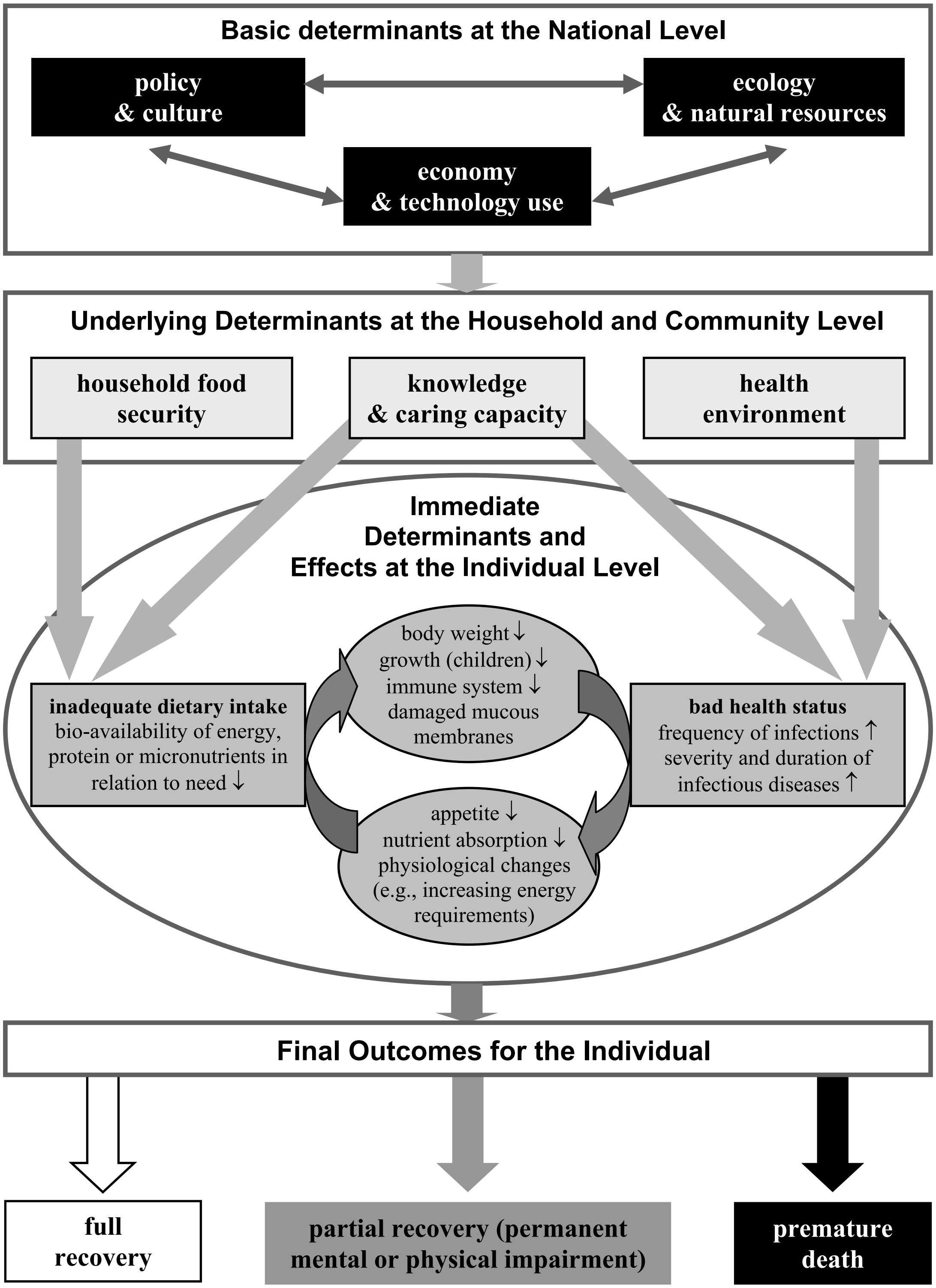
The following section outlines the concept of the GHI, briefly explains the choice of indicators, and demonstrates the added value of the index. Section 3 presents the ranking of countries, and illustrates and discusses regional and country trends. Section 4 exemplifies determinants of hunger like poor macro-economic performance, armed conflict, and AIDS with reference to the GHI. Section 5 concludes with a summary of findings and policy recommendations.

2. The Concept of the Global Hunger Index (GHI)

Hunger has many faces: loss of energy, apathy, increased susceptibility to disease, shortfalls in nutritional status, disability, and premature death (Wiesmann 2004). A conceptual framework for the complex determinants, effects, and outcomes of hunger is shown in Figure 1. Basic determinants at the national level are the interacting fields of economy and technology use, policy and culture, as well as ecology and natural resource endowment. They interact with the underlying determinants at the household and community level: household food security, caring capacity and knowledge, and health environments (Smith and Haddad 2000).

Inadequacies in all or part of these three areas can rapidly push an individual household member into a vicious cycle of insufficient dietary intake, weight loss and reduced immune system, infection, and concurrent physiological changes such as loss of

Figure 1: Determinants, effects, and outcomes of hunger and undernutrition



Source: adapted from UNICEF 1990b, Smith and Haddad 2000, von Braun et al. 1998, Tomkins and Watson 1989.

appetite and energy-consuming fever. This vicious cycle may also be set off by an infectious disease; an unhealthy environment, a lack of knowledge, or a lack of caring capacity can partly offset the positive effect of sufficient food availability on nutritional status. The cycle can conclude with either full recovery or persistent impairment (such as blindness due to vitamin A deficiency or irreversible growth-retardation in children) or death (UNICEF 1990; Tomkins and Watson 1989).

Based on the above conceptual framework, the GHI was designed to capture several dimensions of hunger, which were defined as follows:

- insufficient availability of food (as compared to requirements),[4]
- shortfalls in nutritional status, and
- premature mortality caused directly or indirectly by undernutrition.

This definition goes beyond insufficient dietary energy availability at the household level, which is the focus of the FAO measure of undernourishment[5] (FAO 1996b). Sufficient dietary energy availability at the household level does not guarantee that food intake meets the dietary requirements of individual household members, nor

[4] Ideally, this definition refers to availability of food at the individual level and thereby includes the component of access to food. In practice, even the timely measurement of food availability at the household level is challenging, due to the constraints imposed by data and methods (FAO 2003). However, high rank correlations of the combination of three indicators relating to the above three dimensions with various international poverty measures can be observed (see the section on the Added Value of the GHI in this chapter). Therefore, the deprivation of parts of the population from basic necessities (including food) is at least implicitly considered in the index that is based on the definition above.

[5] In fact, the FAO measure currently captures a narrow aspect of food security as defined by heads of state and other high-level representatives of the international community at the World Food Summit in 1996: "Food Security exists when all people, at all times, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life" (FAO 1996a, Paragraph 1). General Comment 12 on the right to adequate food, approved by the UN Committee on Economic, Social, and Cultural Rights, puts a bit more emphasis on the aspect of dietary preferences or cultural acceptability: "The Committee considers that the core content of the right to adequate food implies: the availability of food in a quantity and quality sufficient to satisfy the dietary needs of individuals, free from adverse substances, and acceptable within a given culture; the accessibility of such food in ways that are sustainable and that do not interfere with the enjoyment of other human rights" (UNHCHR 1999, Paragraph 8). The present study makes no attempt to measure the cultural acceptability of food in addition to other aspects of food security. Cultural acceptability can be an issue when developing countries refuse to accept genetically modified grains as food aid, like Zambia did in 2002, despite a severe famine in the country.

does it imply that health status permits the biological utilization of food. However, the outcomes of insufficient quantity, quality, or safety of food as well as the consequences of a failure to utilize nutrients biologically are encompassed in the above three dimensional definition.

The Choice of Indicators

While it would be desirable to assign more than one indicator to each of the dimensions defined above, data availability is limited, especially for the prevalence of micronutrient deficiencies (often referred to as "hidden hunger"). Consequently, the following three indicators were selected to represent the three dimensions:

- the proportion of undernourished as estimated by FAO, reflecting the share of the population with inadequate dietary energy intake (i.e., the proportion of people who are food energy deficient),
- the prevalence of underweight in children under the age of five, indicating the proportion of children suffering from weight loss and/or reduced growth, and
- the under-five mortality rate, reflecting partly the fatal consequence of the synergy between inadequate dietary intake and unhealthy environments.

All three indicators were selected to monitor progress toward the Millennium Development Goals (United Nations 2001).[6] A common feature of food energy deficiency, underweight prevalence in children, and child mortality is that they are assumed to be associated with or—in the case of the latter two indicators—partly caused by micronutrient deficiencies. Thus, although no indicator of vitamin or mineral deficiencies can be included in the index due to insufficient data availability, the GHI is expected to reflect micronutrient deficiencies to some extent.

[6] Eradicating extreme poverty and hunger and reducing child mortality are part of the Millennium Development Goals. As specific targets, these goals include halving the proportion of people who suffer from hunger between 1990 and 2015, and cutting back the under-five mortality rate by two-thirds in the same period (United Nations 2001).

The index combines the percentage of people who are food energy deficient, which refers to the entire population, with the two indicators that deal with children under five. This ensures that both the situation of the population as a whole and that of children, a particularly physiologically vulnerable subsection of the population, are captured (Wiesmann 2004). Children's nutritional status deserves particular attention because malnutrition puts them at high risk of permanent physical and mental impairment and death (WHO 1997). Adults who were malnourished as children are less physically and intellectually productive, have lower educational attainment and lifetime earnings, and are affected by higher levels of chronic illness and disability (UNICEF 1998; Behrman, Alderman, and Hoddinott 2004; UNS SCN 2004).

The proportion of undernourished and the prevalence of underweight in children both have the shortcoming that they do not reveal the most tragic consequence of hunger and undernutrition: premature death (Wiesmann 2004). The same level of child malnutrition in two countries can have quite different effects on the proportion of malnutrition-related deaths among children, depending on the overall level of child mortality (Pelletier et al. 1994). This disadvantage of the indicator of child malnutritition is mitigated by the inclusion of the under-five mortality rate (Wiesmann 2004). Clearly, the mortality data comprise other causes of death than malnutrition, and the actual contribution of child malnutrition to mortality is not easy to track because the proximate cause of death is frequently an infectious disease (Pelletier et al. 1994). However, about 53 percent of deaths among children under five worldwide are attributable to undernutrition (Caulfield et al. 2004).[7]

For aggregation into the Global Hunger Index, the three selected indicators are equally weighted; see Box 1 for details on the calculation and the data sources (FAO's reports on the State of Food Insecurity in the World, the WHO Global Database on Child Growth and Malnutrition, and UNICEF's reports on the State of the World's Children,

[7] According to estimates done previous to Caulfield et al. (2004), 55 percent of child deaths can be attributed to undernutrition (Pelletier et al. 1994).

Box 1. Calculation of the GHI and data sources

The calculation of GHI scores is restricted to developing countries and countries in transition for which measuring hunger is considered most relevant. Developed countries are not included, because hunger has been largely overcome in these countries, and overconsumption is considered a much greater problem than lack of food.[1] Table 1 below gives an overview of the data sources for the Global Hunger Index. The first column indicates the reference year of the GHI and the second column specifies the respective number of countries for which the index can be calculated.

Table 1. The data sources for the Global Hunger Index (GHI)

GHI	Number of countries with GHI	Index components: Indicators	Reference years	Data sources
1981	89	- Percentage of undernourished	1979-1981[a]	- FAO 1999a, author's estimates
		- Prevalence of underweight in children under five	1977-1982[b]	- WHO 2006,[c] UN ACC/SCN 1993, author's estimates
		- Under-five mortality rate	1980	- UNICEF 1995
1992	97	- Percentage of undernourished	1990-1992[a]	- FAO 2004, author's estimates
		- Prevalence of underweight in children under five	1987-1992[b]	- WHO 2006,[c] UN ACC/SCN 1993, author's estimates
		- Under-five mortality rate	1992	- UNICEF 1994
1997	118	- Percentage of undernourished	1995-1997[a]	- FAO 2004, author's estimates
		- Prevalence of underweight in children under five	1993-1998[b]	- WHO 2006,[c] author's estimates
		- Under-five mortality rate	1997	- UNICEF 1999
2003	116	- Percentage of undernourished	2000-2002[a]	- FAO 2004, author's estimates
		- Prevalence of underweight in children under five	1999-2003[b]	- WHO 2006,[c] author's estimates
		- Under-five mortality rate	2003	- UNICEF 2005

[a] Three-year average.
[b] Latest survey in this period.
[c] The methodology applied for the WHO Global Database on Child Growth and Malnutrition is described in de Onis and Blössner (2003).

The Global Hunger Index is calculated as follows:

$$GHI = \frac{PUN + CUW + CM}{3},$$

when GHI = Global Hunger Index,
PUN = proportion of the population undernourished (in percent),
CUW = prevalence of underweight in children under five (in percent), and
CM = proportion of children dying before age five (in percent).

All three index components are expressed in percentages, and the results of a principal components analysis suggest equal weighting. Higher GHI scores indicate more hunger. The index varies between a minimum of 0 and a maximum of 100. However, the maximum value of 100 would only be reached if all children died before their fifth birthday, the whole population was undernourished, and all children under five were underweight. Likewise, the minimum value of zero does not occur, because this would not only necessitate 0 percent of undernourished in the population, but also that no child under five was underweight and that no child died before its fifth birthday. Even the most highly developed countries have under-five mortality rates greater than zero; see Appendix B Table 18.

[1] The following selection criteria were applied: the GHI was not calculated for countries where dietary energy supply per capita exceeded 2,900 kcal (average 1995-97) and the under-five mortality rate was below 1.5 percent (15 per 1,000 live births) in 1997. Exceptions to this rule are Kuwait, Malaysia, and Slovakia, which were included because of particular hunger-related characteristics; see Wiesmann (2004) for further explanations and also for the rationale of the selection criteria.

and supplementary estimates). Further details on the choice of indicators, the rationale for equal weighting, and the statistical properties of the index are reported in Appendix A.

The Added Value of the GHI

As compared to using a group of single indicators (e.g., the three components of the GHI), a composite index like the GHI has several advantages:

1. An index composed of different but related indicators is able to integrate different aspects of a multifaceted phenomenon like hunger and undernutrition.
2. The combination of indicators measured independently from each other reduces the impact of random measurement errors on the resulting index.
3. By condensing information from complementary indicators, an index is conducive to a quick overview and facilitates the use of statistics by policymakers and the public.
4. Indices have proven to be powerful, "eye-catching" tools for advocacy. If used in international rankings, they can foster a sense of competition among countries and thus help to promote good policies (Streeten 1994; Ryten 2000).

The most commonly used measure of hunger is the FAO indicator of the proportion of undernourished in the population. The FAO method of estimating this number is based on three parameters: dietary energy supply per capita (derived from macro-data on agricultural production, net trade flows and stock changes, as well as uses other than food consumption), the variation of dietary energy intakes across households, and minimum dietary energy requirements (FAO 1996b).[8] This simple method captures shortfalls in dietary energy supply, which are an important aspect of hunger, and data are

[8] See Smith, Alderman, and Aduayom (2006) for the application of an alternative methodological approach based on household expenditure surveys to data from 12 Sub-Saharan African countries for individual years between 1994 and 2001.

released annually and on an almost worldwide scale.[9] However, there are concerns about measuring other aspects of hunger.

In comparison to the three single indicators included in the GHI (the FAO estimates of the proportion of undernourished, the prevalence of underweight in children and child mortality), the added value of the GHI mainly consists in the following characteristics:

- broader conceptual basis (better reflection of multidimensional nature of hunger).
- the food supply situation of the total population is considered (via the FAO estimates) *and* the special vulnerability of children to nutritional deprivation is taken into account (via the indicators of child mortality and child malnutrition[10]).
- inequality of interhousehold food allocation is considered (through the proportion of undernourished as an index component[11]) *and* inequitable intrahousehold resource allocation is factored in (because the latter affects the physical well-being of children).
- the consequences of some micronutrient deficiencies like anemia in pregnant women (an indicator of iron deficiency) and goiter in children (an indicator of iodine deficiency) are better reflected through combining the three index components; the under-five mortality rate has the strongest association with vitamin A deficiency among the indicators considered, but the composite index gets close (see Figure 2).

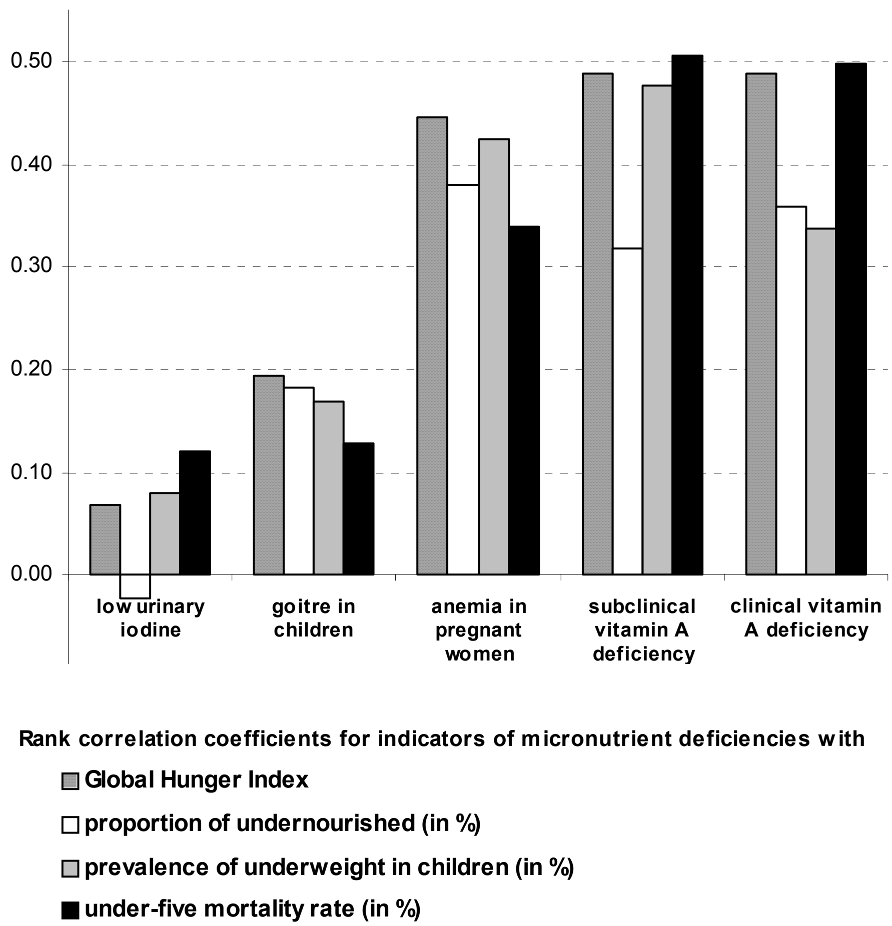
[9] The FAO data on undernourishment are not available for industrialized nations and small countries with less than one million inhabitants.

[10] During humanitarian emergencies, wasting in children (low weight for height, which also translates into low weight for age, i.e., underweight in children) and child mortality can increase quickly. By including underweight prevalence in children and the under-five mortality rate, the index should be able to capture the occurrence of large-scale humanitarian crises.

[11] Ranking differences between the proportion of undernourished and GNP per capita and their relationship to the Gini coefficient and other measures of distribution were analyzed in Wiesmann (2004). Results of this analysis showed that the proportion of undernourished had a higher sensitivity to equi-distribution than a combination of the two indicators on child malnutrition and child mortality.

- the correlation with important international poverty measures is higher for the GHI than for its components (see Figure 3), which shows the ability of the index to take into account the deprivation from basic necessities in a population.

Figure 2: The strength of the association of the GHI and its components with indicators of vitamin and mineral deficiencies

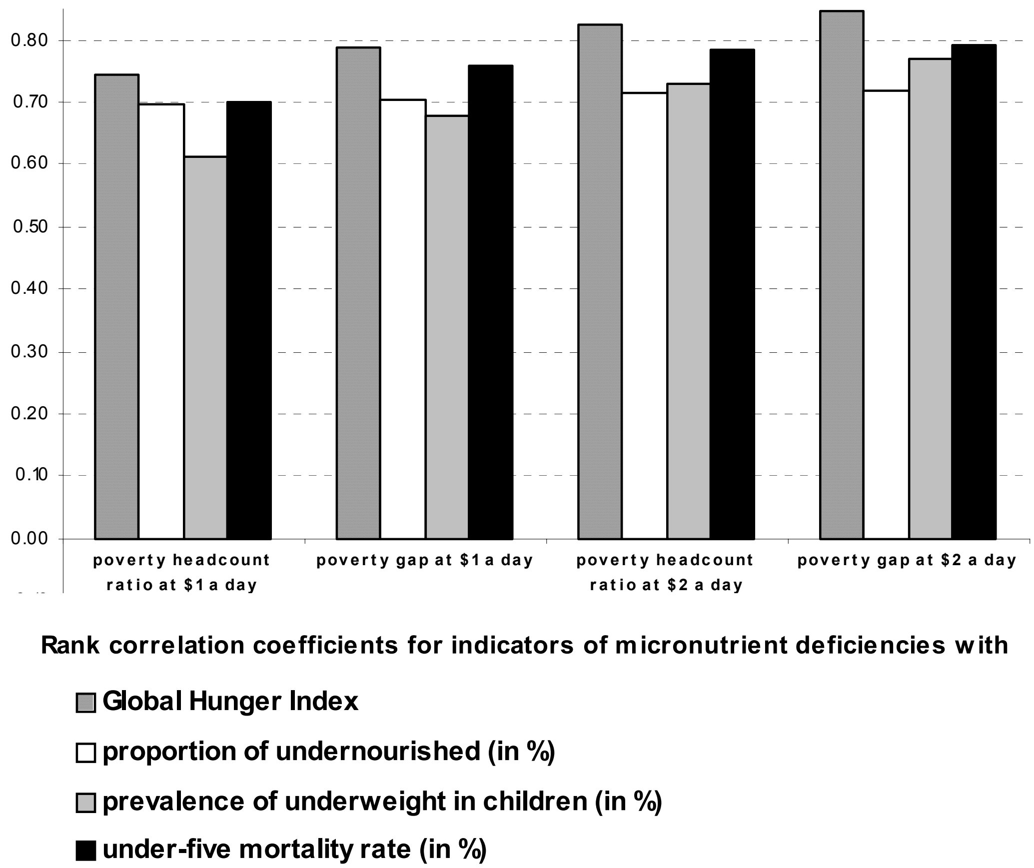


Source: Author's calculations; see Appendix B Table 16 for the data sources.

Notes: Low urinary concentration of iodine and goiter in children are indicators of iodine deficiency. Iron deficiency is one possible cause of anemia in pregnant women. Subclinical vitamin A deficiency is traced by low serum retinol levels. Clinical vitamin A deficiency, which is the more severe form, is diagnosed by observing characteristic eye changes that can lead to blindness.

Rank correlation coefficients can vary between – 1 and + 1. The more the correlation coefficient approaches 1, the stronger the association between the Global Hunger Index and a given indicator of micronutrient deficiencies. Details on the data used, number of observations, and p-values are shown in Appendix B Table 16.

Figure 3: The strength of the association of the GHI and its components with four measures of absolute poverty



Source: Author's calculations; see Appendix B Table 17 for the data sources.

Notes: The poverty headcount ratio at $1 a day indicates the proportion of the population living on less than $1.08 a day at 1993 international prices; the poverty headcount ratio at $2 a day indicates the proportion of the population living on less than $2.15 a day at 1993 international prices. The poverty gap is the mean shortfall from the poverty line (counting the nonpoor as having zero shortfall), expressed as a percentage of the poverty line. This measure reflects the depth of poverty as well as its incidence (World Bank 2005).

Rank correlation coefficients can vary between – 1 and + 1. The more the correlation coefficient approaches 1, the stronger the association between the Global Hunger Index and a given poverty measure. Details on the data used, number of observations, and p-values are shown in Appendix B Table 17.

The first three points in the above list and the discussion above show that the three components of the GHI complement each other because they reflect different aspects of hunger. From a conceptual perspective, the GHI can provide a more balanced view than the undernourishment estimates alone, because the biological utilization of food and the impact of caring and feeding practices on children's nutritional status are implicitly taken into account (Wiesmann 2004). The relatively high correlations of the GHI with indicators of micronutrient deficiencies are illustrated in Figure 2. The favorable characteristics of the GHI will be referred to in the discussion of the GHI ranking and trends in the next section.

3. Global Hunger Index: Ranking and Trends

GHI scores are used in the present section for a ranking of countries and a world hunger map. Furthermore, GHI scores show trends in food security and nutrition for countries and regions. As already mentioned, the index can take scores from 0 (best case) to 100 (worst case).[12] GHI scores can be roughly classified: scores greater than 10 indicate a serious problem, scores greater than 20 are alarming, and scores exceeding 30 are extremely alarming.

Before turning to the ranking of countries, it has to be emphasized that while the GHI scores are surely influenced by the realization of basic human rights, and particularly economic, social, and cultural rights (such as the right to food, medical care, and other basic necessities, the right to social security and protection, equal access to public services, special care and assistance for motherhood and childhood, education and gender equity—compare the conceptual framework in Figure 1), the concept of the index is not based on an explicit human rights perspective. Such an approach would make the inclusion of indicators of political freedom and civil liberties mandatory (respective indicators are also not part of the Human Development Index; see UNDP 2005). Both democracies and authoritarian regimes have shown the willingness to pursue hunger reduction strategies and the ability to implement related policies efficiently. For these reasons, the GHI ranking should not be misinterpreted as a rating of political systems.

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[12] However, these theoretically possible extreme scores do not occur in practice; see Box 1 for further explanations.

Ranking and Mapping of Countries

The Global Hunger Index ranking of countries for 2003[13] is shown in Table 2, with the best performers at the top of the list (omitting developed countries). The international ranking of 119 developing countries and countries in transition ranges from a minimum GHI score of 1.6 to a maximum score of 42.7, covering about 41 GHI points. Higher GHI scores indicate more hunger; the mean GHI score is 15.0.

Belarus is at the top of the list with a GHI of 1.6 (the child malnutrition data for this country are based on the author's preliminary estimates, however), and is closely followed by Argentina, Chile, Ukraine, and Romania. Countries that experienced long-lasting violent conflicts affecting the infrastructure, the productive base of the economy, and the population's livelihoods have very high GHI scores, indicating grave outcomes in terms of hunger and undernutrition. Nine out of the 12 countries at the very bottom of the list—Burundi, the Democratic Republic of Congo, Eritrea, Ethiopia, Sierra Leone, Angola, Liberia, Cambodia, and Tajikistan—were affected by war in the GHI reference period or are still recovering from severe conflicts (UCDP 2006). [14]

Warfare was frequently accompanied by economic mismanagement, such as excessive price controls, and barriers to internal trade and market development that were set up by the state. A few examples of war-torn countries with damaging economic policies in the 1990s are Angola, Ethiopia (formerly including Eritrea),[15] and

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[13] The most recent year for which the GHI can be calculated is 2003. Due to the time needed to collect and process the data, the publication of international data lags behind by two to three years. For example, the most recent estimates of the proportion of undernourished that FAO released in 2005 referred to the average of the years 2000-2002, and they were identical with the estimates published by FAO in 2004 (FAO 2004; FAO 2005).

[14] These conflicts were mostly civil wars, except for the interstate war between Eritrea and Ethiopia from 1998 to 2000, and the war in the Democratic Republic of Congo, in which other states in the region were also involved (UCDP 2006).

[15] Ethiopia would probably take a lower place in the ranking if the country did not receive considerable amounts of food aid from the international community: in 2000-2002, about 7 percent of dietary energy supply in Ethiopia was provided by food aid. This share is even larger for North Korea, where food aid in cereals alone accounted for about 17 percent of dietary energy availability in 2003 (author's calculations based on data from FAO 2006b).

Table 2: Global Hunger Index (GHI)—Ranking of countries

	GHI rank	Country	Global Hunger Index 1981	1992	1997	2003
	1	Belarus	..	..	3.71	**1.59** *
	2	Argentina	2.87	1.87	2.93	**1.81**
	3	Chile	3.87	3.93	2.37	**1.87**
	4	Ukraine	..	..	3.71	**1.97**
x	**5**	Romania	..	3.89	2.36	**2.07**
	6	Libya	6.37	4.80	**2.40**	..
	7	Tunisia	9.00	5.03	4.43	**2.47**
	8	Cuba	4.63	5.83	7.62	**2.57**
	9	Lithuania	..	..	2.47	**2.64** *
x	**10**	Croatia	..	..	3.84	**2.72**
	11	Latvia	..	..	3.46	**2.74** *
	12	Uruguay	4.57	5.20	3.50	**2.74**
X	**13**	Russian Federat.	..	..	3.80	**2.93**
	14	Fiji	..	7.14	5.97	**3.07**
	15	Slovak Republic	..	..	3.87	**3.22** *
	16	Lebanon	8.67	5.10	3.23	**3.28**
	17	Costa Rica	5.63	3.30	**3.50**	..
X	**18**	Kuwait	5.87	9.90	2.67	**3.56**
	19	Estonia	..	..	2.70	**3.56** *
	20	Mauritius	14.07	8.47	7.73	**3.80**
	21	Syrian Arab Rep.	8.77	7.17	6.73	**4.23**
X	**22**	Bosnia & Herzeg.	..	..	5.56	**4.60**
	23	Jordan	7.34	4.47	4.83	**4.73**
X	**24**	Serbia & Monten.	..	..	2.29	**4.77**
x	**25**	Mexico	9.93	7.50	5.99	**5.10**
x	**26**	Egypt	13.63	6.63	7.00	**5.17**
	27	Jamaica	7.07	6.67	5.43	**5.27**
	28	Brazil	10.43	8.50	6.70	**5.43**
	29	Saudi Arabia	8.97	6.87	7.40	**5.44**
X	**30**	Turkey	9.77	7.07	4.93	**5.45**
x	**31**	Iran	12.00	9.00	5.80	**5.80**
x	**32**	Macedonia, FYR	..	..	6.50	**5.93**
x	**33**	Paraguay	8.70	8.37	**6.16**	..
x	**34**	Ecuador	13.70	10.13	7.73	**6.22**
x	**35**	Moldova	..	..	6.93	**6.32** *
x	**36**	Morocco	13.70	7.20	7.40	**6.42**
X	**37**	Algeria	13.83	7.13	7.57	**6.50**
	38	Trinidad & Tobago	6.33	7.30	7.73	**6.63**
	39	Albania	9.71	9.18	7.62	**7.23**
	40	Malaysia	12.67	10.17	7.73	**7.23**
X	**41**	Colombia	14.87	9.70	8.13	**7.27**
	42	South Africa	..	7.46	7.32	**7.66**
x	**43**	Venezuela	6.13	6.17	7.93	**7.83**
X	**44**	Peru	19.23	19.73	10.80	**7.83**
	45	Kazakhstan	..	..	4.96	**8.17**
X	**46**	El Salvador	16.63	11.17	9.80	**8.17**
	47	China	20.10	12.57	8.57	**8.23**
	48	Kyrgyz Rep.	..	..	10.34	**8.36**
	49	Gabon	16.17	13.63	10.83	**9.00**
	50	Suriname	..	..	9.39	**9.37**
	51	Guyana	..	15.17	12.83	**9.83**
X	**52**	Azerbaijan	..	..	14.89	**10.27**
	53	Turkmenistan	..	..	11.40	**10.40**
	54	Dominican Rep.	16.13	14.10	12.40	**11.27**
X	**55**	Georgia	..	..	9.17	**11.53**
	56	Bolivia	18.73	17.27	14.07	**11.57**
x	**57**	Panama	13.60	11.33	11.03	**12.21**
x	**58**	Thailand	23.37	17.83	13.80	**12.36**
x	**59**	Indonesia	28.17	18.53	15.60	**12.47**
x	**60**	Lesotho	18.87	16.13	14.57	**12.80**
x	**61**	Armenia	..	..	12.19	**13.30**
x	**62**	Nicaragua	16.93	16.44	16.97	**13.47**
x	**63**	Uzbekistan	..	..	11.74	**13.60**
	64	Honduras	20.73	16.47	16.97	**14.03**
	65	Swaziland	..	11.17	14.00	**14.87**
	66	Ghana	35.87	27.03	18.67	**14.87**
	67	Mongolia	18.50	18.10	24.68	**15.83**
X	**68**	Myanmar	25.20	19.33	15.53	**16.17**
X	**69**	Sri Lanka	24.90	22.40	21.87	**16.63**
	70	Guatemala	24.73	17.37	17.70	**16.87**
	71	Namibia	18.19	23.03	22.32	**17.50**
X	**72**	Philippines	22.40	21.80	19.63	**17.55**
	73	Benin	29.00	19.40	20.97	**17.77**
x	**74**	Côte d'Ivoire	13.03	14.23	17.43	**18.13**
	75	Vietnam	32.20	25.93	22.37	**18.37**
	76	Botswana	23.93	18.53	16.37	**18.57**
X	**77**	Uganda	24.63	21.83	21.73	**18.63**
	78	Gambia	..	20.37	21.97	**18.83**
x	**79**	Nigeria	30.00	22.47	20.90	**19.17**
x	**80**	Cameroon	18.20	19.93	21.17	**19.52**
	81	Mauritania	30.30	27.73	17.43	**20.03**
x	**82**	Senegal	20.17	19.70	19.90	**20.13**
	83	Korea, Dem. Rep.[a]	19.35	15.51	20.91	**20.33**
x	**84**	Djibouti	..	32.09	24.45	**20.90**
x	**85**	Togo	23.90	23.70	21.23	**21.10**
	86	Kenya	19.40	23.13	22.93	**21.73**
x	**87**	Guinea	27.00	28.67	24.64	**21.73**
x	**88**	Pakistan	33.60	25.97	23.60	**21.77**
	89	Timor-Leste[b]	..	..	..	**22.29**
	90	Zimbabwe	22.00	21.87	23.50	**23.20**
x	**91**	Lao PDR	29.53	25.83	26.73	**23.83**
X	**92**	Nepal	43.30	27.77	27.77	**24.50**
x	**93**	Haiti	34.63	35.03	33.23	**25.33**
	94	Malawi	25.40	33.40	30.47	**25.40**
X	**95**	Sudan	23.47	27.43	22.80	**25.67**
X	**96**	India	41.23	32.80	25.73	**25.73**
	97	Burkina Faso	40.27	21.03	22.87	**25.80**
X	**98**	Guinea-Bissau	30.75	22.74	25.39	**26.61**
X	**99**	Rwanda	27.23	31.87	32.10	**27.20**
X	**100**	Chad	42.17	36.50	35.87	**27.33**
x	**101**	Mali	41.43	25.37	31.97	**28.07**
x	**102**	Bangladesh	44.40	36.50	35.73	**28.27**
x	**103**	Central Afric. Rep.	31.63	33.27	30.50	**28.43**
X	**104**	Mozambique	41.57	47.17	34.97	**28.83**
X	**105**	Yemen	38.90	27.23	30.70	**29.19**
	106	Madagascar	23.23	30.90	31.93	**29.92**
	107	Tanzania	22.33	27.83	31.63	**29.97**
X	**108**	Tajikistan	..	..	19.86	**30.25**
X	**109**	Cambodia	46.43	33.03	36.03	**30.73**
x	**110**	Comoros	..	26.58	29.55	**30.81**
	111	Zambia	21.77	31.13	30.57	**31.77**
X	**112**	Liberia	22.10	25.27	30.66	**32.00**
X	**113**	Angola	27.13	40.83	38.17	**32.17**
x	**114**	Niger	37.67	38.53	41.20	**33.43**
X	**115**	Sierra Leone	31.10	33.20	33.70	**35.20**
X	**116**	Ethiopia[c]	39.20	46.44	41.72	**36.70**
X	**117**	Eritrea	..	..	41.10	**40.37**
X	**118**	Congo, Dem. Rep.	28.43	28.00	38.37	**40.83**
X	**119**	Burundi	27.73	32.30	39.71	**42.70**

(continued)

Table 2 (continued)

Source: See Table 1 in Box 1 of Chapter 2 for the data sources of the GHI; source of information on violent conflicts: UCDP 2006.

Notes: * GHI scores contain author's preliminary estimates of the underweight prevalence in children under five years. GHI 1997 was used to rank Costa Rica, Libya, and Paraguay, because GHI 2003 could not be calculated for these countries. Ten countries could not be included due to lack of (recent) data: Afghanistan, Bahrain, Bhutan, Bulgaria, Congo (Republic), Iraq, Oman, Papua New Guinea, Qatar, and Somalia. x = Countries experienced a minor or intermediate armed conflict between 1989 and 2003, but no war. **X** = Countries waged a full-blown war between 1989 and 2003.

[a] North Korea.

[b] East Timor.

[c] For years earlier than 1993, when the secession of Eritrea took place, numbers for Ethiopia included the area of Eritrea.

Mozambique (Reichel 1991; Azam, Collier, and Cravinho 1994). With a GHI of 42.7, Burundi ranks lowest in the international comparison of index scores, which largely results from 10 years of conflict from 1993 to 2003[16] that was motivated by ethnic tensions, from internal displacement of large population groups, and from a weak economy dependent on subsistence agriculture, and coffee and tea exports (UCDP 2006; CIA 2006; see, also, Messer and Cohen [2006] for a discussion on trade of primary agricultural commodities and its role in triggering conflict). Since the beginning of the 1980s, hunger has continuously increased in Burundi (see Table 2 and Appendix B Table 18). A recently completed study by IFPRI estimates the proportion of the population that is food energy deficient based on representative data on household expenditures. Among the 12 Sub-Saharan African countries that were investigated, Burundi ranks second lowest before Ethiopia (Smith, Alderman, and Aduayom 2006).

Niger, Zambia, and Comoros are among the bottom 12 countries, although they were not engaged in wars between 1989 and 2003. In Niger, minor armed conflicts took place between 1992 and 1997 (UCDP 2006), and the country is part of the ecologically vulnerable Sahel zone with irregular rainfalls. The consequences of the famine in Niger in 2005, which resulted from protracted drought and a plague of locusts, are not captured in the present GHI for 2003. Comoros is one of the poorest countries in the world and is characterized by scarce natural resources, lack of infrastructure, and political instability. Since independence in 1975, the country has witnessed frequent coups d'état or attempts to overthrow the government (UCDP 2006).

Zambia indirectly suffered from the long-lasting civil wars in Angola and Mozambique, which created an influx of refugees from these neighboring countries (UCDP 2006). Zambia also has one of the highest HIV prevalence rates in the world, amounting to almost 17 percent in 2003 (UNAIDS/WHO 2006). The disease continues

[16] The conflict continued beyond this year, but, of course, only the period up to 2003 is relevant for the GHI 2003. In September 2006, a cease-fire deal was signed by Burundi's last rebel group and the government, but it is not yet clear if this will end the violent tensions between the dominant Tutsi minority and the Hutu majority on the long term.

to ravage the country's economic, political, and social development. In addition, Zambia has become impoverished and increasingly indebted in recent decades due to the declining price of copper, its major export commodity. However, economic reforms implemented in the 1990s give reason for new hope for Zambia's economic development (CIA 2006; World Bank 2005).

The ranking shows that countries rank worse when inadequate food availability also translates into high child malnutrition and child mortality rates. The combination of lack of food, poor nutritional status, and high mortality creates an even more urgent situation and calls for more immediate interventions than food insufficiency alone. As already mentioned, a child's risk of death from malnutrition increases when overall mortality levels increase (Pelletier et al. 1994).

To use an illustrative example, among the 119 countries considered, Yemen's proportion of undernourished is 36 percent (ranked 101), its underweight prevalence in children is 40.3 percent (ranked 110), and the child mortality rate is 11.3 percent (ranked 84). For Niger, the proportion of undernourished is 34 percent (ranked 97), the underweight prevalence is 40.1 percent (ranked 108), and the child mortality rate is 26.2 percent (ranked 118), more than double that of Yemen. This means that child malnutrition, although at equal levels in these two countries, is much more likely to have fatal consequences in Niger than in Yemen. Consequently, there is an even greater urgency for intervention in Niger than in Yemen. This is reflected in the ranking according to the GHI: Yemen is ranked 105th and Niger, 114th. If child mortality was not considered in the index, however, the two countries would have almost identical ranking positions, with Niger being rated slightly better than Yemen.

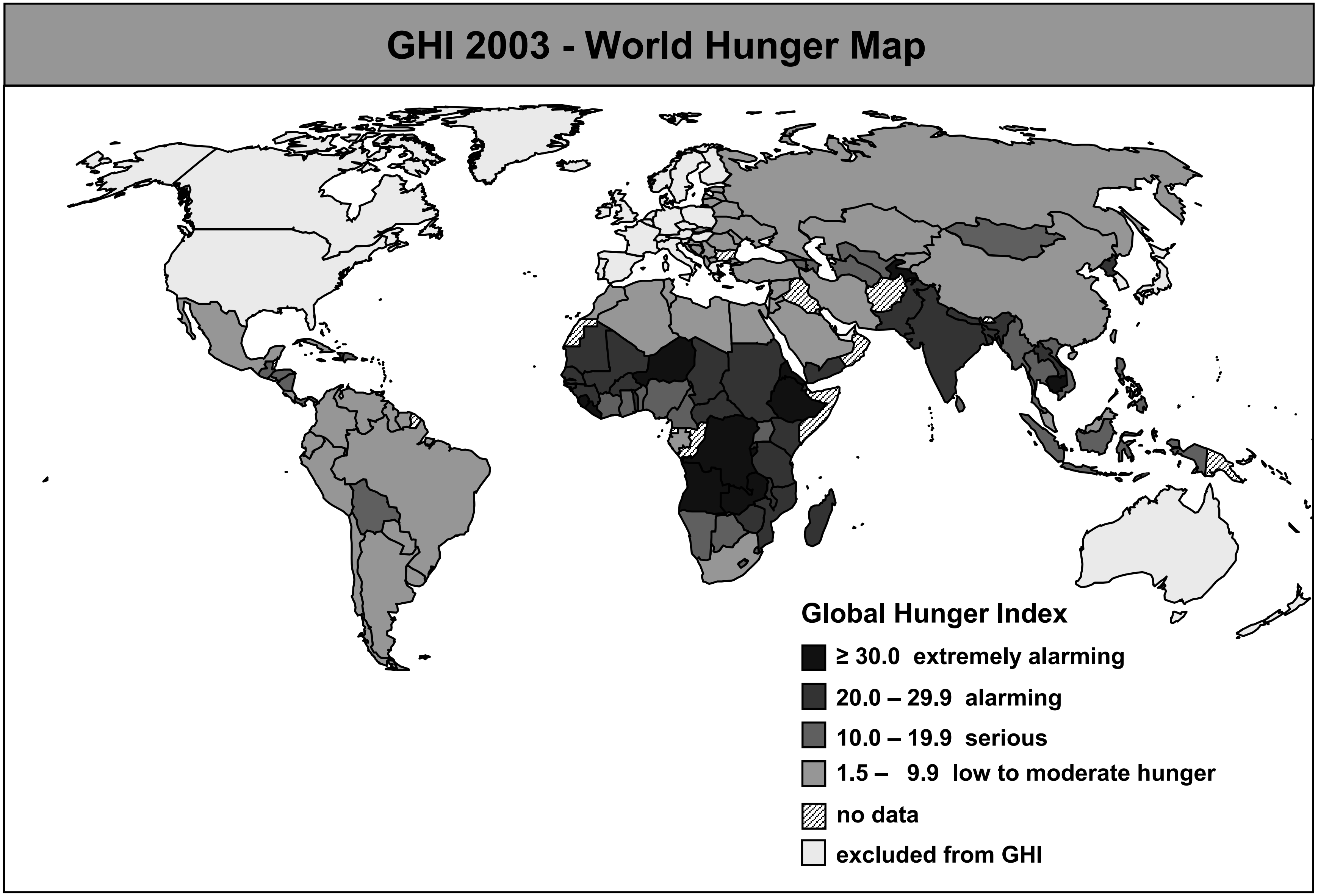
The following additional examples, in which the GHI components have quite different ranks, illustrate the value added of the GHI; if only one of the three indicators was considered, certain aspects of the problem of hunger and undernutrition would be missed. India ranks 70th according to the proportion of undernourished and 73rd according to the under-five mortality rate, for example, but only 117th of 119 countries on underweight in children. Mainly due to its poor performance with regard to child malnutrition, India ranks 96th on the Global Hunger Index. The GHI score of 25.7 classifies it as a country with alarming levels of hunger and undernutrition.

Similarly, high underweight prevalence in children has a negative impact on Malaysia's GHI score and ranking position. Malaysia does very well with regard to the proportion of undernourished and the under-five mortality rate (it ranks 5th of 119 countries on the first indicator and shares first place with Croatia on the second indicator), but ranks 71 on underweight in children. Therefore, the country only ranks 40 on the GHI. In contrast, Paraguay ranks favorably with regard to underweight prevalence in children (ranked 8), but does comparatively poorly on the proportion of undernourished and the under-five mortality rate (ranked 54 and 40, respectively). The resulting GHI rank is 33. For a more systematic analysis of the information content of the index as compared to its components, see the rank correlations in the section on Technical Notes on Redundancy in Appendix A.

The world hunger map 2003 in Figure 4 clearly shows that the hot spots of hunger are in Sub-Saharan Africa and South Asia. There are few exceptions to this rule: Haiti in the Caribbean; Yemen in the Near East; Tajikistan in Central Asia; Laos, Cambodia, Timor-Leste (East Timor) in Southeast Asia; and the Democratic Republic of Korea in East Asia also have GHI scores higher than 20. The rampant poverty in these regions and countries is the major reason for widespread hunger and high rates of child malnutrition and child mortality.

However, a comparison of GHI scores for 2003 with GHI scores for 1992 (see the world hunger map for 2003 in Figure 4 and the world hunger map for 1992 in Figure 5, and Table 2) illustrates considerable progress in this decade: some countries and even entire regions are on track to escape the vicious cycle of poverty and hunger. Examples are large parts of the Andean region in South America, several West and Central African countries like Ghana and Chad (despite a new, minor armed conflict that started in 1998 [CIA 2006] and excluding recent refugees from Darfur), and also some East and Southern African countries with high GHI scores, but notable recent reductions in hunger (e.g., Ethiopia, Mozambique, and Angola, where major wars have come to an end). Positive

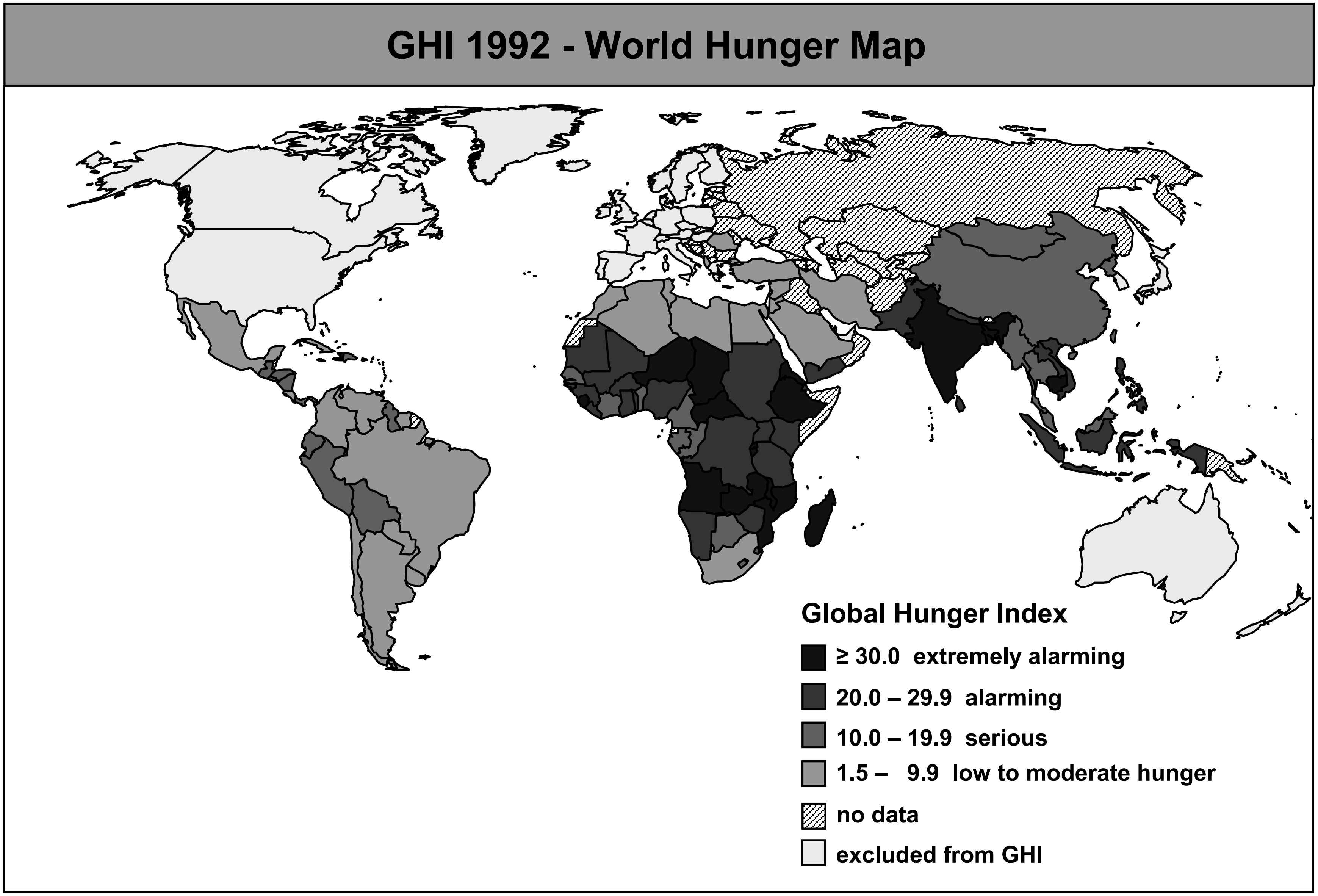
Figure 4: Global Hunger Index 2003—Mapping of countries



Source: Author's presentation; see Table 1 in Box 1 for the data sources.

Note: For Costa Rica, Libya and Paraguay, GHI 1997 was used due to lack of data for GHI 2003.

Figure 5: Global Hunger Index 1992—Mapping of countries



Source: Author's presentation; see Table 1 in Box 1 for the data sources.

trends can be observed throughout most of South and Southeast Asia, including India and China. Regional and country trends are addressed in more detail in the following section.

Regional Comparisons and Trends

Highly aggregated regional GHI scores can easily conceal disparities within subregions and among countries.[17] Therefore, the following overview for the regions is further differentiated in Figure 6, where countries are grouped by regions and ranked by their GHI 2003. While an exhaustive discussion of individual countries is beyond the scope of this study, the trends and patterns in selected countries will be briefly described.

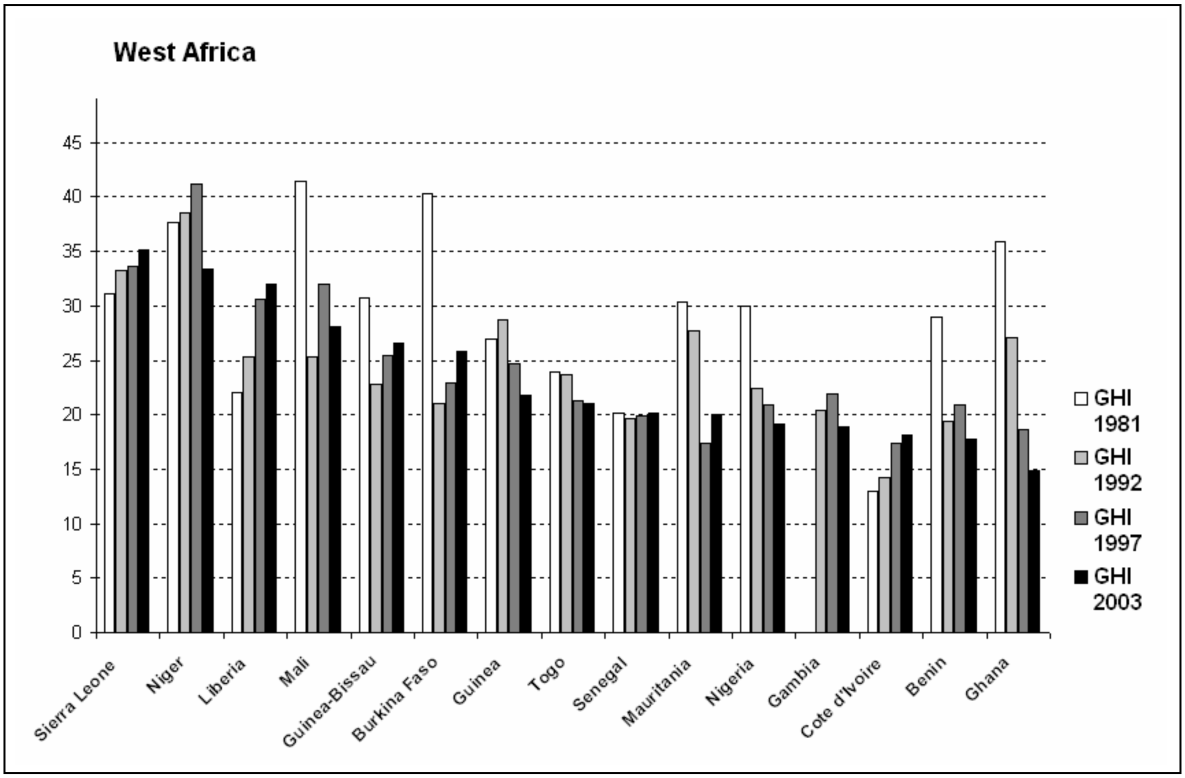
Among the regions considered,[18] **Sub-Saharan Africa** has the highest regional GHI for 2003 and ranks lowest (closely followed by South Asia; compare Figure 7). Overall progress from 1981 to 2003 was smallest in this region. Despite the relatively high initial GHI level of about 28 in 1981, its score decreased by only 2.5 points in this period, indicating a modest reduction in hunger (see Figure 7). Declines in the proportion of undernourished and the under-five mortality rate by 6.4 and 3.2 percentage points, respectively, were partly outweighed by rises in underweight prevalence in children (+ 2.1 percentage points; see Figure 8). Fortunately, the trend of rising child malnutrition was reversed between 1997 and 2003.

Large disparities are found within this region: both the country with the largest reduction of hunger and the country with the highest increase in hunger are located in Sub-Saharan Africa. The GHI for Ghana dropped by 21 points from 1981 to 2003, while hunger soared in Burundi and its GHI rose by about 15 points during the same period. In Ghana, the percentage of undernourished was reduced from 61 percent in 1979-81 to 13

[17] Particularly countries with large populations and covering vast, diverse areas should be subject to subnational disaggregation of index scores in the future, because pockets of hunger and poverty can persist in countries for which national aggregates of the GHI look favorable. Of course, China and India would be the primary candidates for such a disaggregation, but smaller countries with zones of ongoing serious conflict, like Darfur in Sudan and the Northern region in Uganda, should be considered as well.

[18] Details on the regional aggregation of GHI scores are described in Appendix C.

Figure 6: GHI trends 1981-2003, by country



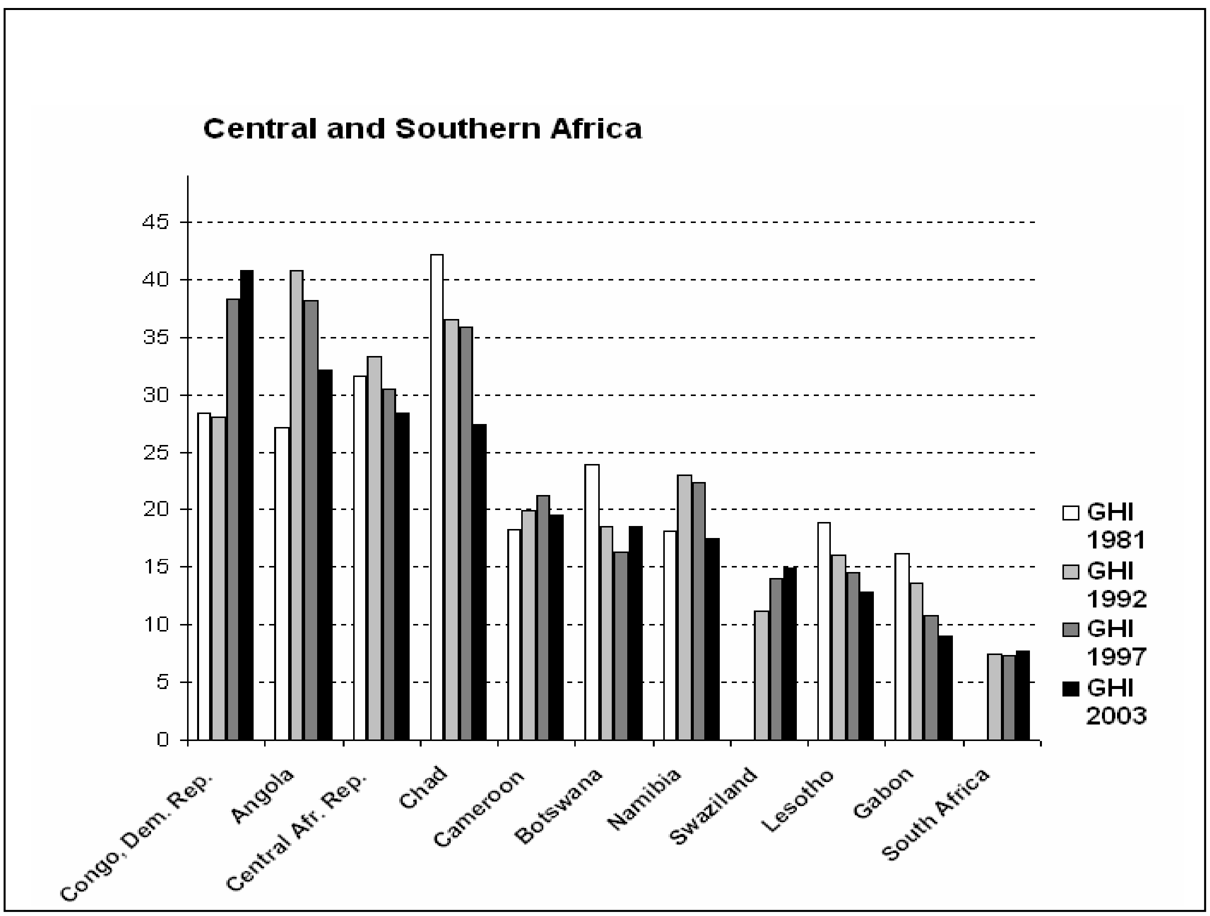


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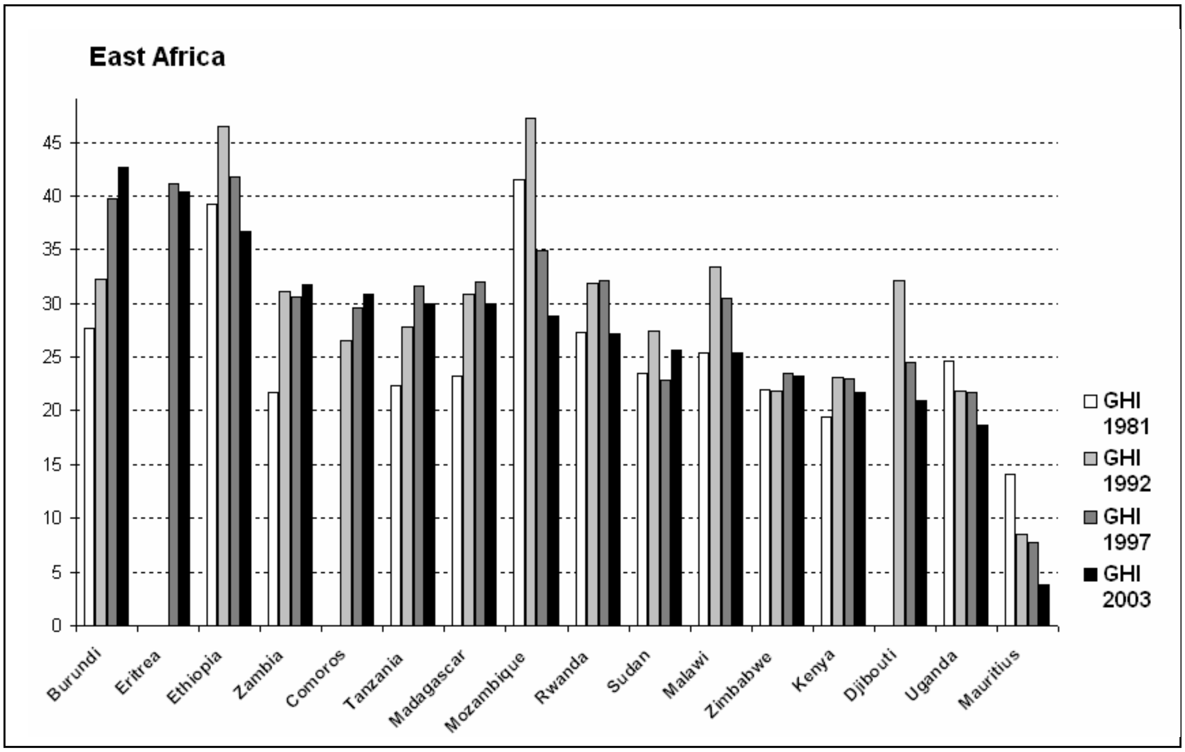
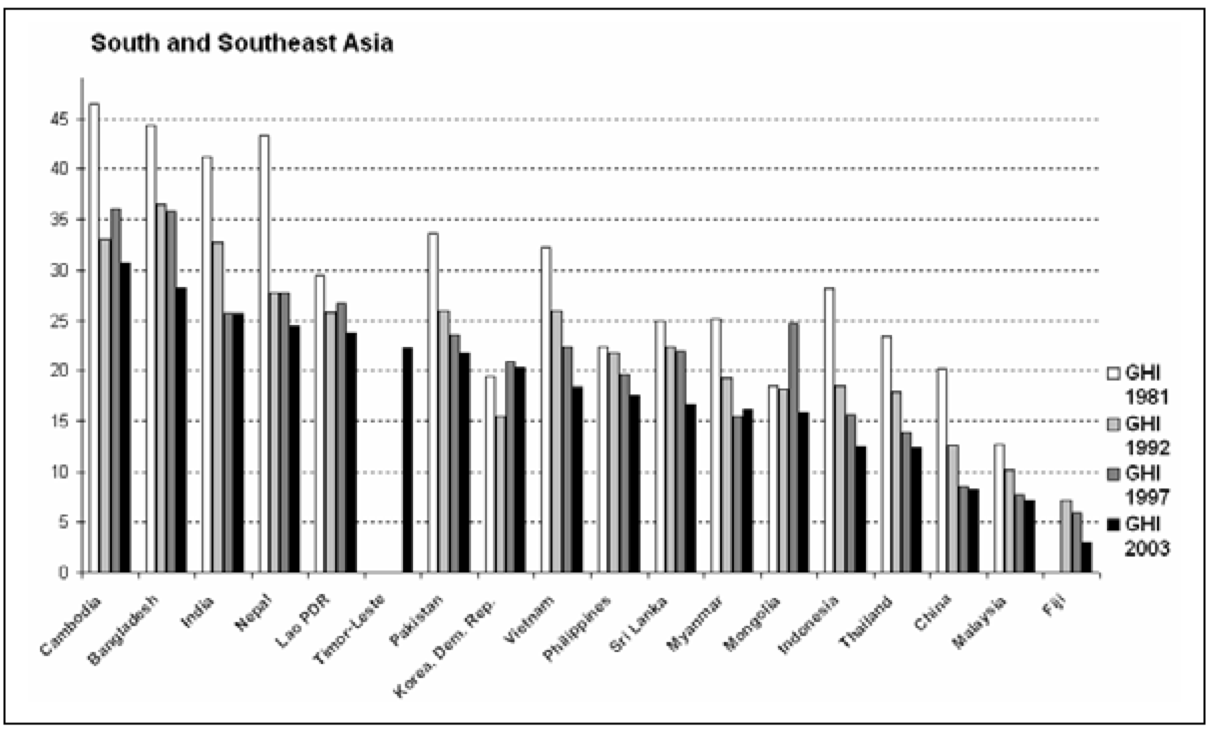
Figure 6 (continued)





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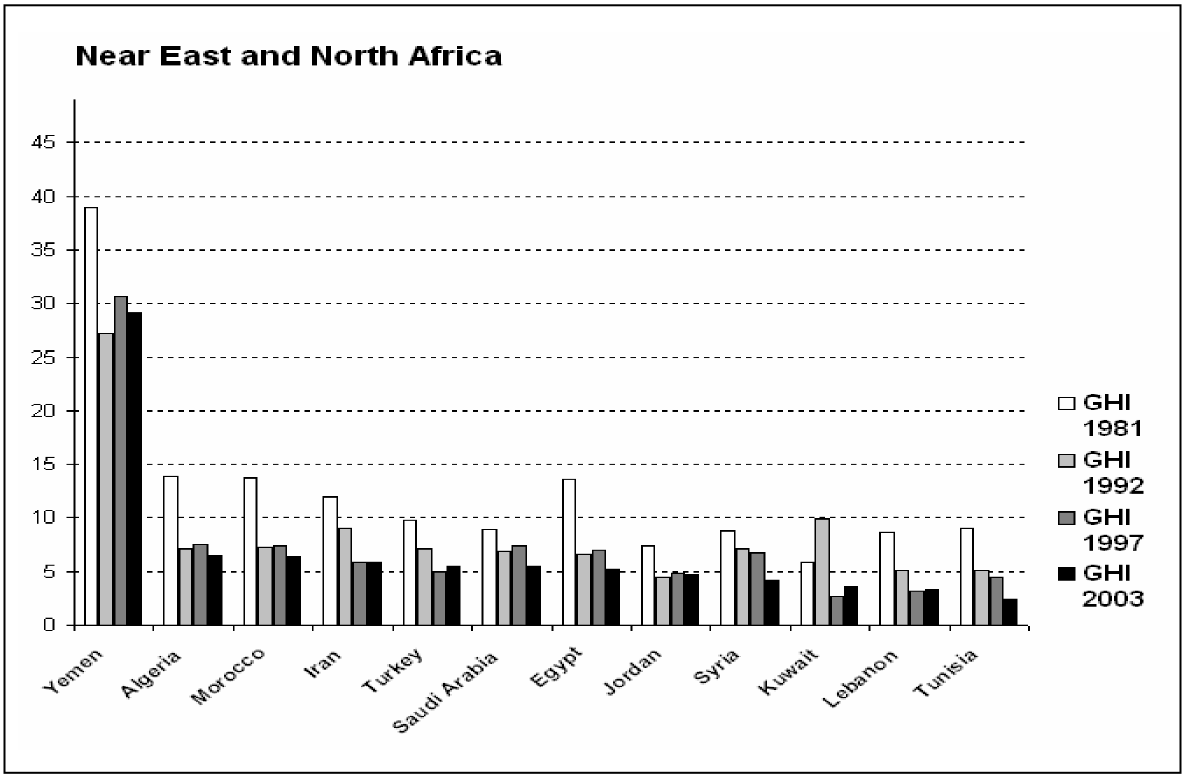

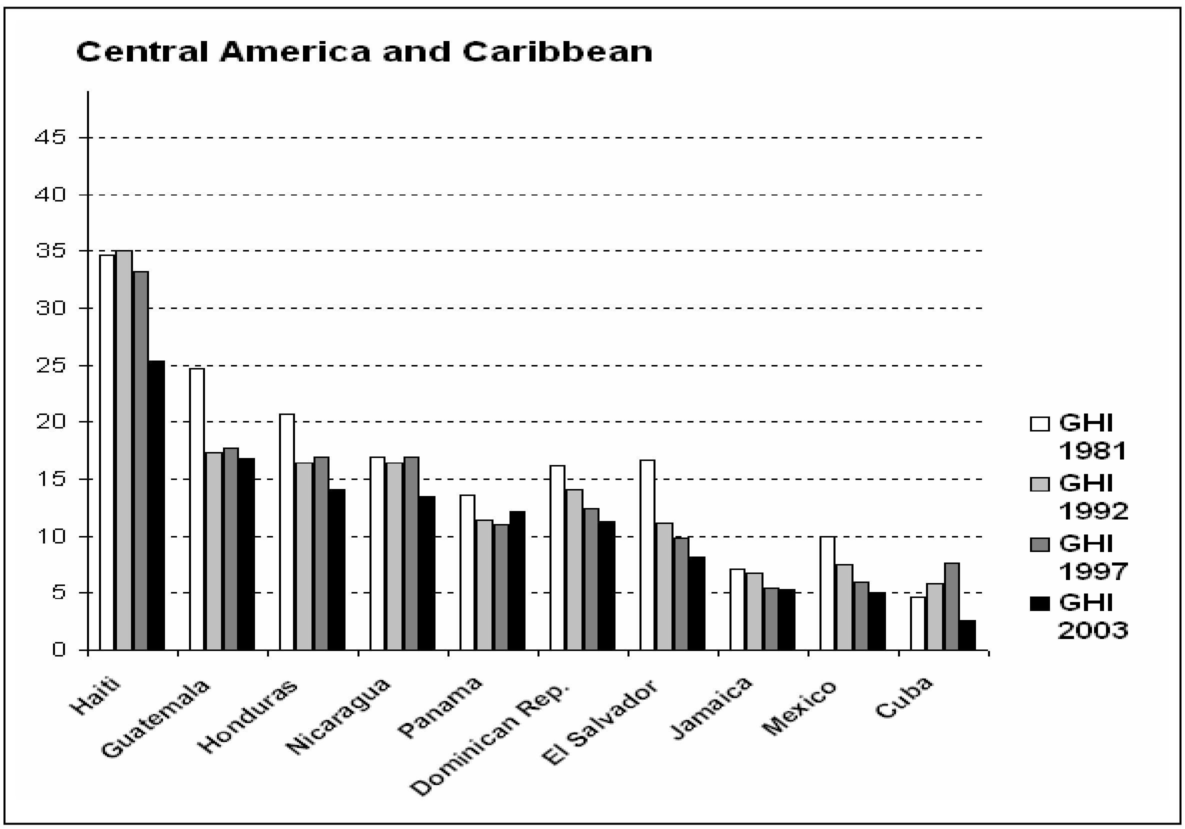

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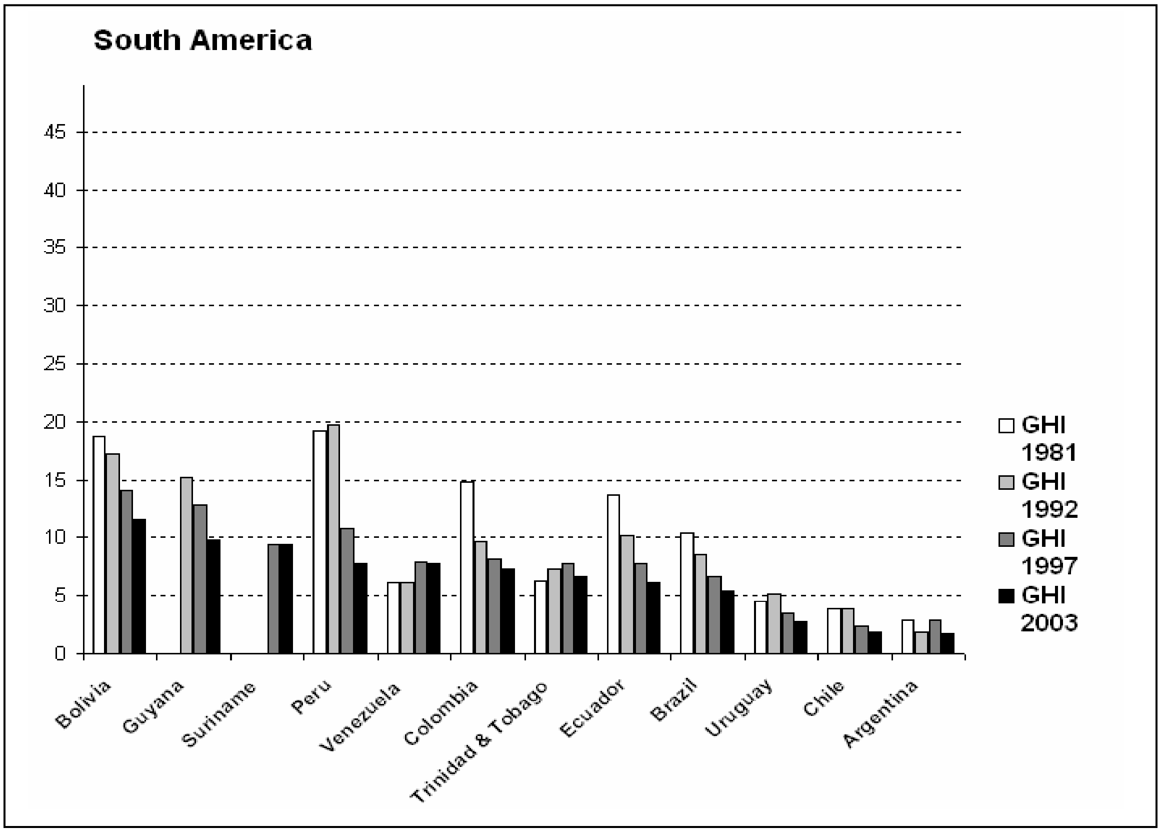
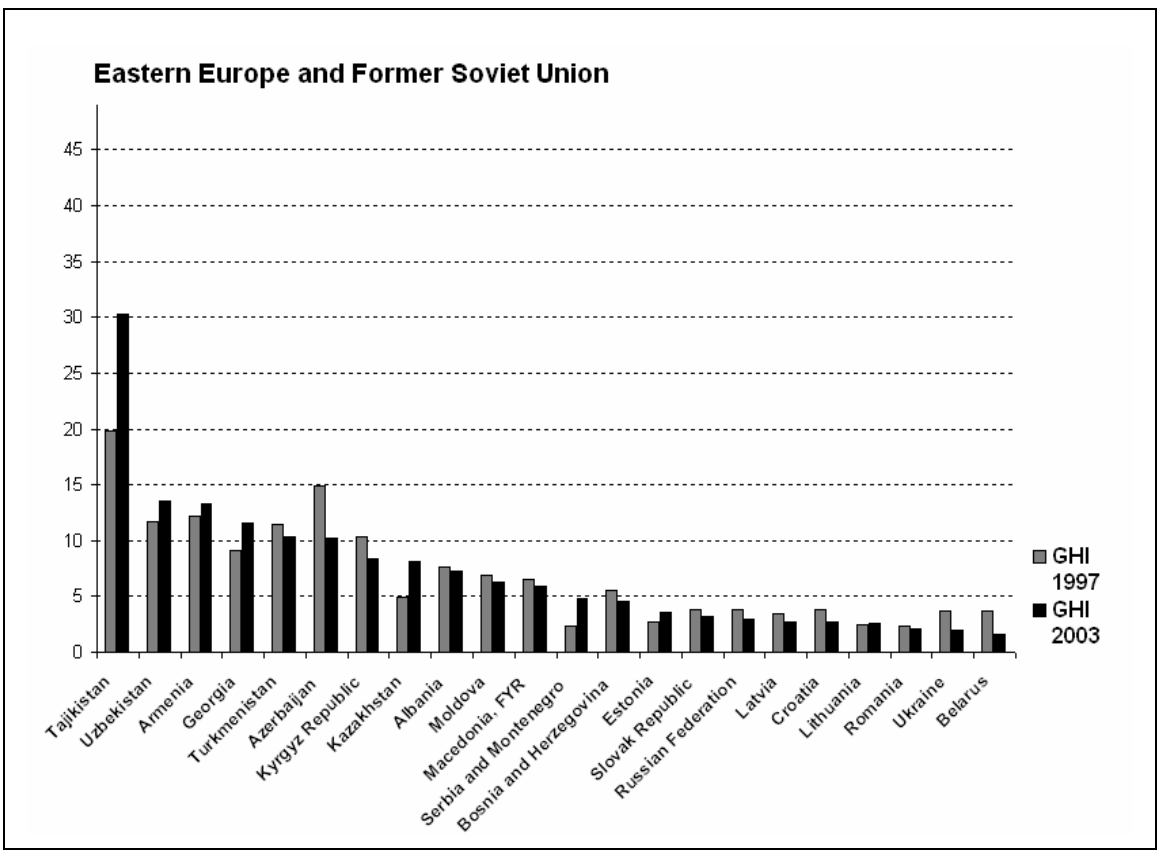
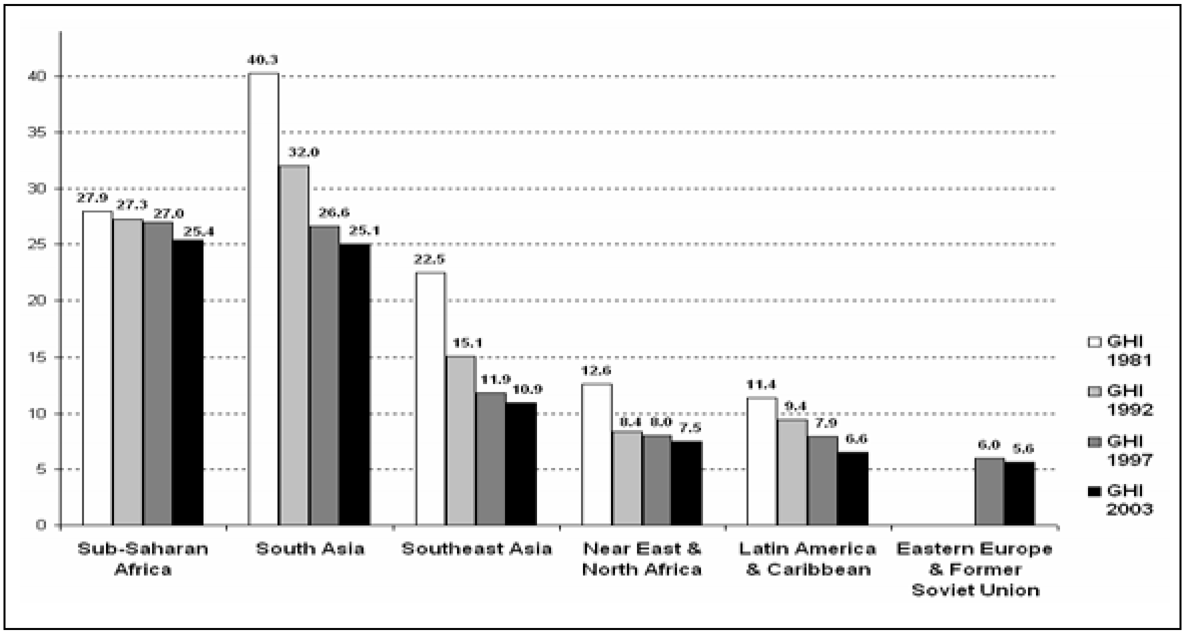




Source: Author's calculation; see Appendix B Table 18 for the data that were used, and Table 1 in Box 1 for the data sources.

Figure 7: Regional GHI trends 1981-2003



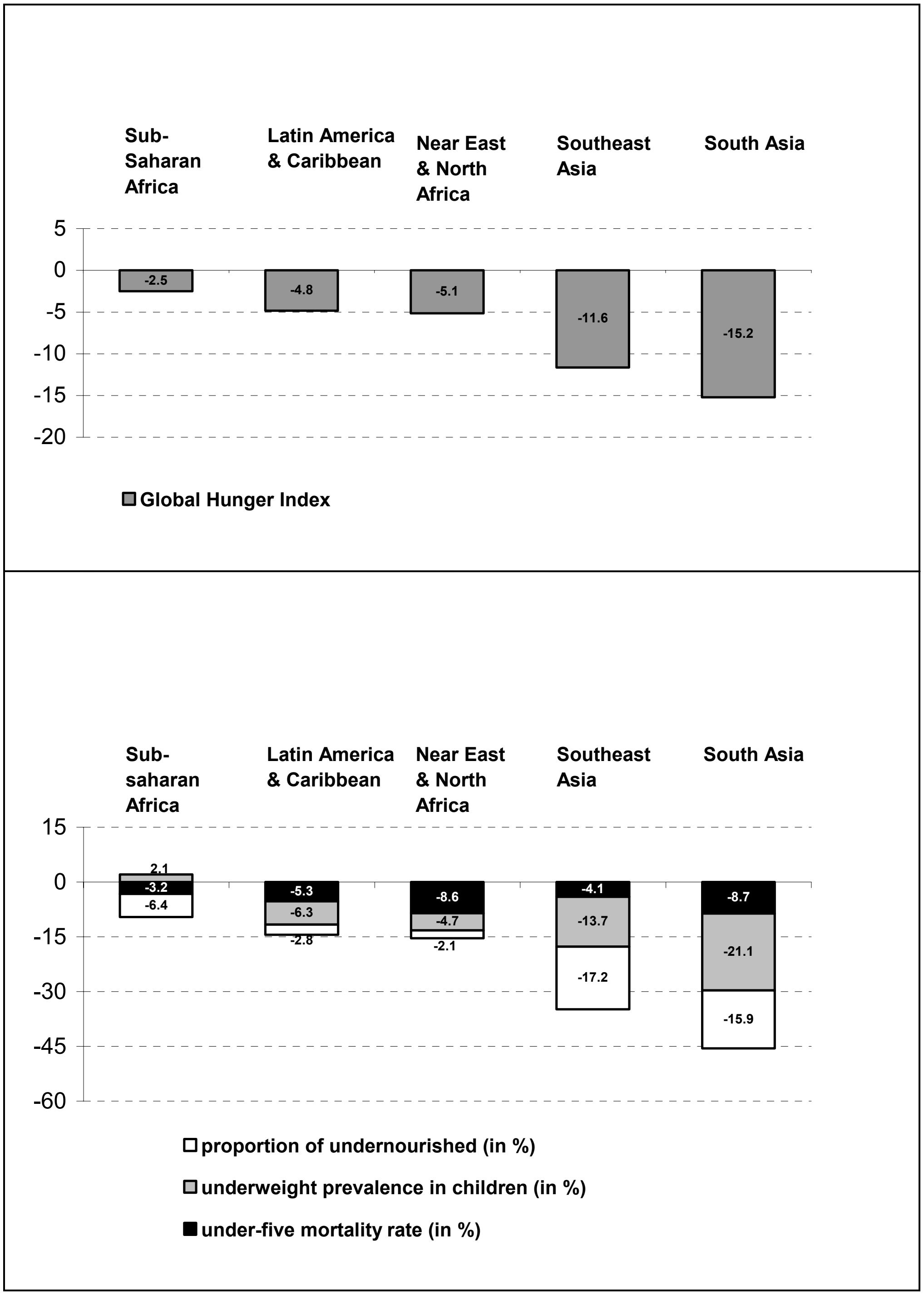
Source: Author's calculation; see Table 1 in Box 1 and Appendix C Table 19 for the data sources.

Note: For Eastern Europe and the Former Soviet Union, only data for 1997 and 2003 are available.

percent in 2000-2002. The introduction of improved yams, maize, rice and cassava varieties, an increase in the cropped area by about one-quarter, and rapid economic growth in other sectors helped to boost food supply in Ghana (FAO 1999a). Marked improvements in access to sanitation, health, and education were also achieved during that period (FAO 1999a). Accordingly, the under-five mortality rate fell from 15.7 percent in 1980 to 9.5 percent in 2003 and the prevalence of underweight in children decreased by about 9 percentage points; see Appendix B Table 18. In several other West African countries—in Benin and Nigeria,[19] for example—hunger was also reduced considerably from 1981 to 2003.

[19] The progress in Nigeria is noteworthy, since the country was affected by political instability and corruption during part of this period (CIA 2006). Yet, in spite of long-standing ethnic, religious, and regional tensions, a peaceful transition to a civilian government took place in 1999, after 30 years of military rule. It was only in 2004—after the reference year for the latest GHI score—that two minor armed conflicts erupted, which could be ended relatively quickly (UCDP 2006).

Figure 8: Regional changes in the GHI and its components from 1981 to 2003



Source: Author's calculation; see Table 1 in Box 1 and Appendix C Table 19 for the data sources.

Notes: When calculating the Global Hunger Index, the sum of its three components is divided by three. This explains the difference in the scale of the two graphs (0 to -20 for the GHI changes, and 0 to -60 for the changes of the components).

In Liberia, Côte d'Ivoire, and Sierra Leone, however, the GHI rose by about 10, 5, and 4 points, respectively, in the same period. Liberia and Sierra Leone experienced political instability and armed conflict in the 1990s, which reached the intensity of full-blown civil war within two years (UCDP 2006). In Côte d'Ivoire, once the richest country in West Africa, the economy started to recede in the early 1980s (World Bank 2005). Austerity measures introduced by the government in 1990 spurred unprecedented political upheaval, and the economic recession gave rise to the beginning of ethnic tensions. In 1999, the first coup d'état in Côte d'Ivoire's history was staged. The country plunged into political instability, and endured armed conflict from 2002 to 2004, further undermining the economy (UCDP 2006).

Whereas the Democratic Republic of Congo in southern Africa also experienced rising hunger due to political turmoil and violent conflict in the 1990s, Mozambique underwent considerable recovery after the civil war that had ravaged the country for more than 15 years ended in 1992. The notable decrease in the GHI for Mozambique is based on declines in all three index components. After a peace agreement was signed in 1992, the government committed itself to rebuilding the country's infrastructure and to improving living standards, with poverty reduction as the primary goal (Simler et al. 2004).

In two other war-affected countries, Angola and Ethiopia, negative GHI trends were reversed in the 1990s. Ethiopia still receives large amounts of food aid (FAO 2006b) and continues to remain vulnerable to climatic shocks. While the proportion of people who are food energy deficient declined considerably in Ethiopia between 1981 and 2003, the prevalence of underweight in children rose by 9.1 percentage points, compensating for a fall in the under-five mortality rate by 9.1 percentage points (see

Appendix B Table 18). Thus, more children survived, but were likely to do so in a malnourished state.[20]

In Ethiopia, high levels of child malnutrition were found in food surplus and food deficit regions, and household food production and food security is neither a strong nor a consistent predictor of child nutritional status. Improvements in household income and food security are aims in themselves, but fail to translate into improved child nutrition if poor health and childcare practices persist (compare the conceptual framework in Figure 1). Whereas attention to household food-related problems is necessary, it is not a sufficient response to the problem of child malnutrition. More emphasis should be given to tackling other causal factors prevalent in rural Ethiopia, such as high rates of child morbidity, poor water and sanitation conditions, a variety of infant and child feeding problems, and high rates of female illiteracy (Pelletier et al. 1995).

In contrast to the sluggish overall development in Sub-Saharan Africa, **South Asia** and **Southeast Asia** made great strides in combating hunger from 1981 to 2003. In 1981, the GHI for South Asia indicated that the entire region was in alarmingly bad condition with regard to hunger and undernutrition: the score was 40.3, about the same as the latest GHI score for Eritrea, the country with the penultimate ranking position in 2003. Thus, South Asia's GHI score was 44 percent higher than Sub-Saharan Africa's (see Figure 7). By 2003 South Asia's regional score had caught up with Sub-Saharan Africa. Notable reductions in undernourishment (about 16 percentage points), underweight prevalence (about 21 percentage points), and child mortality (about 9 percentage points) led to a large decrease of 15.2 GHI points in this period.

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[20] The equal weighting of the components raises the question of whether the index would be able to show an improvement for the hypothetical scenario that more children survived, but all of them in a malnourished state (assuming that the only factor bringing about changes in the child malnutrition rate are the children who would have died under previous conditions, but now survive). The answer is yes, since the child mortality rate is expressed as a proportion of the cohort of children born at a given point in time, whereas child malnutrition is referenced to all children under five. Thus, for the above hypothetical scenario, the prevalence of underweight in children would inevitably increase less than the under-five mortality rate decreased, thereby resulting in a lower GHI score. For the example of Ethiopia, this implies that other factors besides more children surviving, but in a malnourished state, must have contributed to the observed increases in child malnutrition.

Starting from a much lower GHI of about 23, Southeast Asia also experienced a considerable reduction of 11.6 points from 1981 to 2003. For this part of the Asian region, the contribution of reduced undernourishment in the total population to the overall improvement was slightly larger (a drop of 17 percentage points) and the contribution of the two indicators relating to children was smaller (reductions by about 14 and 4 percentage points for underweight prevalence and under-five mortality, respectively). As Figure 6 shows, the Democratic Republic of Korea is the only country in the region for which hunger increased from 1981 to 2003. However, its rise in the GHI would probably be far surpassed by Afghanistan if data had been available to calculate the index for this South Asian country.[21]

China and India, the world's population giants in South Asia and East Asia, made large contributions to the overall positive development in these two regions. Cereal yields quadrupled in China and more than doubled in India between 1961 and 1997 (FAO 1999b), and undernourishment declined considerably. Moreover, China's and India's economies grew at impressive rates: in China, Gross National Income (GNI) per capita (in international dollars, which take the purchasing power of local currencies into account) increased almost sixfold from 1980 to 2003, and more than doubled in India during that period (World Bank 2005). The proportion of the population with access to safe water was already high in China in the early 1980s (86 percent), but increased notably in India by the 1990s (from 54 percent to 81 percent) (World Bank 2000). Child malnutrition was reduced by about 13 percentage points in China and by more than 20

[21] According to earlier data that were used for the Nutrition Index (the predecessor of the Global Hunger Index), the situation in Afghanistan deteriorated dramatically from the early 1980s to the end of the 1990s (see Wiesmann 2004). Several factors, most of them related to continuous warfare, contributed to the desperate situation: the population increased by 25 percent between 1980 and 1996, partly due to returning refugees. Cereal production fell slightly because more than 40 percent of arable land in Afghanistan is mined and cannot be farmed. The war-affected economy was unable to generate imports to fill the gap. The prevalence of underweight in children was estimated to be about 21 percent in 1980, and amounted to almost 50 percent in 1997 (see Appendix B Table 18). Women, who are the main caretakers of children as a nutritionally vulnerable group, were deprived of their rights and opportunities by war, legislation, and custom, particularly after the Taliban had seized power in 1996 (FAO 2002). In 1997, 50 percent of men and 81 percent of women were illiterate (World Bank 2000), and 2 percent of the population had been landmine casualties (FAO 1999a).

percentage points in India, whereas the under-five mortality rate was cut back by more than 40 percent in China and was halved in India from 1981 to 2003.

Yet, the lack of improvement in India's GHI score between 1997 and 2003 despite annual growth rates in GNI per capita of 3-7 percent[22] gives reason for concern, especially when considering that India's GHI still indicates alarming levels of hunger and undernutrition.

The varying impact of the Green Revolution (i.e., the introduction of high-yielding rice and wheat varieties together with irrigation, fertilizer, and pesticides in the 1960s) partly explains the contrasting development in Sub-Saharan Africa and Asia. The Green Revolution was far more successful in Asia than in Sub-Saharan Africa, where this technology package was not widely applied (von Braun 1996). Poor infrastructure, high transport costs, limited investment in irrigation, and unfavorable pricing and marketing policies made the Green Revolution technologies too expensive or inappropriate for much of Africa (Hazell 2003). Consequently, cereal yields increased by 160 percent in Asia from 1961 to 1997, but by only 50 percent from a lower initial level in Africa within the same period (FAO 1999b).

Despite its heavily criticized negative side-effects on the environment and mixed outcomes for small farmers, the Green Revolution thus had a sizable positive impact: rapid agricultural output growth in Asia boosted economic growth and public investment in rural areas, benefiting food security and nutrition. Higher incomes and lower prices permitted people not only to consume more dietary energy, but also a more diversified, higher-quality diet with larger shares of fruits, vegetables, and animal products (Hazell 2003).

In the **Near East and North Africa,** the GHI had quite a low level of about 13 in 1981 and fell by about 5 points by 2003. The largest change occurred between the beginning of the 1980s and the early 1990s, with minor declines in the following decade. In contrast to the Southeast Asian example quoted above, a decrease in child mortality

[22] Based on author's calculations with data from World Bank (2005).

mainly contributed to this change for the better (the under-five mortality rate dropped by about 9 percentage points from 1981 to 2003). Food availability was already at a high level in 1981, which is evidenced by a proportion of undernourished of only about 8 percent at this point in time. The share of undernourishment slightly decreased by 2 percentage points by 2003, while underweight prevalence in children was reduced by almost 5 percentage points.[23]

In this region, Yemen is lagging behind; its GHI is more than 20 points higher than that of other countries in the Near East and North Africa. The country also shows an inconsistent trend over the 1981-2003 period. The war between Kuwait and Iraq in 1990-91 is reflected in the increase in hunger in Kuwait between 1981 and 1992. However, the transient shortfall in food supply that resulted from this interstate conflict and that drove the rise in the GHI 1992 was overcome relatively quickly.

In **Latin America and the Caribbean**, there was sustained progress from 1981 to 2003, though not at a great pace: the GHI declined by 4.8 points. In 1981, the GHI score amounted to 11.4. The proportion of undernourished, underweight prevalence and child mortality were falling slowly since the early 1980s by about 3, 6, and 5 percentage points, respectively. Therefore, the pattern of change is similar to the Near East and North Africa, but with lesser reductions in child mortality (which was, however, at a lower level in Latin America and the Caribbean at the outset). In Latin America, the Green Revolution was also successfully applied and contributed to growing food supplies and incomes (Hazell 2003). On average, there is more hunger in Central America and the Caribbean than in South America, but the situation has been improving for all countries in this subregion from 1981 to 2003 (see Figure 6).

[23] These estimates exclude Iraq, for which FAO did not publish any new estimates of undernourishment in 2005 and also withdrew all past figures on dietary energy supply per capita. Therefore, no GHI scores could be calculated for this country, which comprises about 7 percent of the region's population. Since child mortality increased by 4.3 percentage points from 1981 to 2003 and underweight prevalence by about 1.4 percentage points in Iraq in the same period, the actual trends for the Near East and North Africa would probably look slightly less favorable if this country could have been included.

Haiti is still lagging behind but has recently been catching up; despite political turmoil and violent conflict in this country, the stagnation in the GHI between 1981 and the 1990s was followed by a decrease in the GHI of almost 8 points from 1997 to 2003. This decline in the index was based on reductions in all three components (see Appendix B Table 18). Considerable progress is also observed for Peru, El Salvador, Guatemala, Colombia, Ecuador, and Bolivia: the GHI decreased by more than 7 points between 1981 and 2003.[24] A slight negative trend of rising hunger is seen for Venezuela.

For **Eastern Europe and the Former Soviet Union**, lack of data for the 1980s and early 1990s prevents observation of long-term trends. Most of these nation states came into existence after the dissolution of the Soviet Union or after the Balkan War in the 1990s. GHI scores for 1997 and 2003 suggest a very minor overall improvement in this period. The GHI is lowest among all regions considered, amounting to 5.6 in 2003. The five Central Asian countries (Tajikistan, Uzbekistan, Turkmenistan, the Kyrgyz Republic, and Kazakhstan) and the three countries affected by the Caucasus conflict (Armenia, Georgia, and Azerbaijan) had more hunger in 2003 than the Eastern European countries that are included in the ranking (see Figure 6).

The dramatic rise in hunger in civil war-ridden Tajikistan between 1997 and 2003 stands out. Dietary energy supply fell from 2,180 to 1,800 kcal per capita from 1995-97 to 2000-2002 in this country, leading to a concurrent rise in the proportion of undernourished by more than 30 percentage points. The under-five mortality rate

[24] This may seem surprising for Colombia, where the Global Hunger Index score fell by 7.6 points from 14.9 in 1981 to 7.3 in 2003, despite a long-lasting armed conflict that reached the intensity of war in 2001 and 2002 (and also in 2004 and 2005). The conflict, largely financed by illicit drug trade, has claimed 40,000 lives in the last decade and has led to the internal displacement of many people (UCDP 2006; CIA 2006). However, the country has witnessed favorable economic trends during the period under consideration. While the proportion of undernourished fell by 9 percentage points (from 22 percent in 1979-81 to 13 percent in 2000-2002), improvements in the health and education sector (World Bank 2005) helped to bring down the underweight prevalence in children from 16.7 percent to 6.7 percent and the under-five mortality rate from 5.9 percent to 2.1 percent (see Appendix B Table 18). El Salvador and Peru are two other countries in Latin America where GHI scores decreased from 1981 to 2003 in spite of armed conflict: the episodes of fighting were shorter than in Colombia and the reductions in GHI scores were larger (-8.5 and -11.4, respectively).

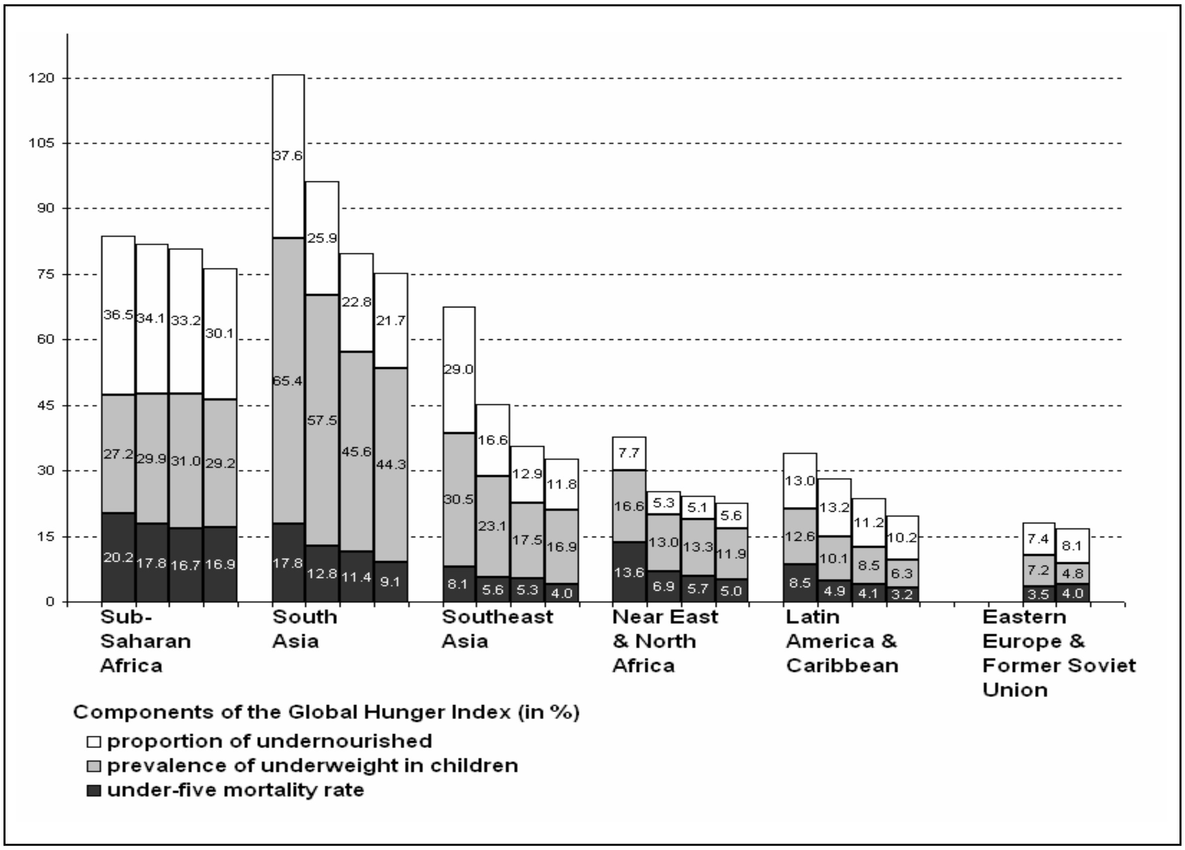
increased by more than 4 percentage points from 1997 to 2002; compare Appendix B Table 18.

Not only do the patterns of change differ among the regions, but also the relative contributions of the three index components, as Figure 9 illustrates. In South Asia, for example, underweight prevalence in children makes up the largest share. In contrast, child mortality and undernourishment in the population play a bigger role in Sub-Saharan Africa. Similar GHI scores in these two regions in 2003 are apparently the outcome of different patterns. The main reason that child malnutrition is still rampant in South Asia and at a higher rate than in drought-stricken, conflict-plagued Sub-Saharan Africa is that women's nutrition and feeding and caring practices for young children are inadequate, which is related to deficiencies with regard to women's education and their status in society (World Bank 2006a; Smith et al. 2003).

Therefore, the status of women and their knowledge about caring and feeding practices need to be addressed in South Asia to further reduce child malnutrition. According to a recent study in Bangladesh, intensive nutrition education for mothers improves child nutritional status significantly and sustainably even when no nutritional supplements are provided, and this effect is attributable to changes in maternal child-feeding and caring practices (Roy et al. 2005). Food shortage and a high prevalence of life-threatening infectious diseases are major problems that have to be tackled in Sub-Saharan Africa. This illustrative comparison shows that the GHI captures a fuller picture than any of the three single indicators could reflect in isolation.

The comparison of GHI components in the Near East and North Africa on the one hand and Latin America and the Caribbean on the other is another interesting example: while the GHI 2003 is in the same range of about 7, underweight in children is more prevalent than undernourishment in the total population in the Near East and North Africa, and vice versa in Latin America and the Caribbean. For the former region, the low status of women in Arab countries may partly explain why the prevalence of child malnutrition exceeds the share of the population with insufficient dietary energy availability. Research has shown that low status of women in a society is one of the determinants of underweight in children (Smith and Haddad 2000; Smith et al. 2003). In contrast, in Eastern Europe and the Former Soviet Union, where women are usually highly educated and have high rates of participation in the labor force, the prevalence of child malnutrition is lower than the proportion of undernourished in the population.

Figure 9: Regional trends in GHI components (years 1981, 1992, 1997, and 2003)



Source: Author's calculation; see Table 1 in Box 1 and Appendix C Table 19 for the data sources.

Notes: For Eastern Europe and the Former Soviet Union, only data for 1997 and 2003 are available. When calculating the Global Hunger Index, the sum of its components is divided by three, which explains the difference in the scales of this figure and Figure 7.

4. Selected Determinants of Hunger

The following section briefly examines the following causes of hunger and undernutrition, as measured by the GHI: poor macroeconomic performance, warfare, and HIV/AIDS. Other determinants of food security and nutrition, like investment in health and education services, democracy and good governance, and women's status have been extensively investigated elsewhere (Wiesmann 2004; Smith and Haddad 2000; Smith et al. 2003).

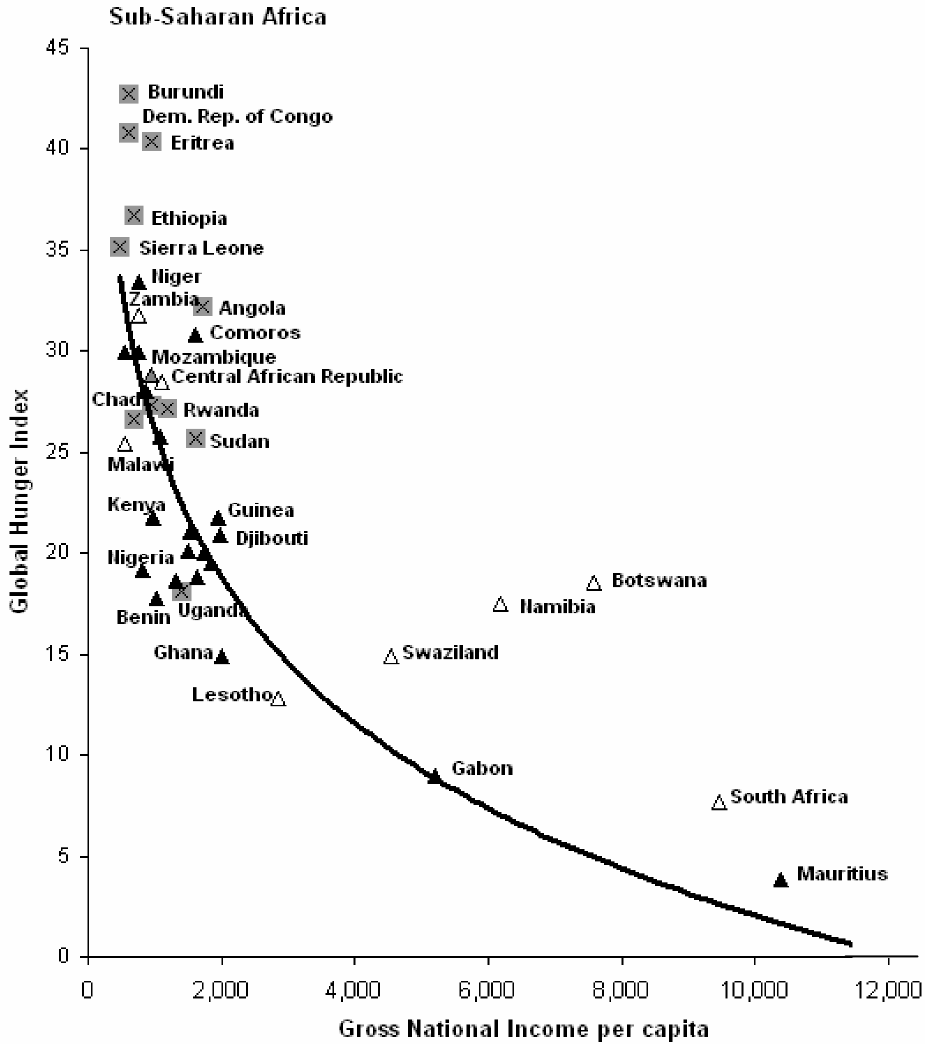
Poor Macroeconomic Performance

National incomes are central to food security and nutrition, because household food security, knowledge, and caring capacity as well as health environments require a range of goods and services to be produced by the national economy or to be purchased on international markets (Smith and Haddad 2000). There is also a strong relationship between national incomes and poverty. Consequently, Gross National Income (GNI) per capita is used to predict GHI scores for 2003 (see Figure 10, where actual and predicted GHI scores are plotted against GNI per capita). This scatter plot does indeed show a strong association between the two indicators: poor countries tend to have high GHI scores.

The graph also permits the identification of countries that do notably better in terms of the GHI than GNI per capita suggests. These are the countries with GHI scores far below the predicted scores (the black line). Conversely, countries that do considerably worse than expected from their level of economic development have much higher GHI scores than predicted. The differences between actual and predicted scores are used to evaluate countries' performance in converting economic resources into gains in food security and nutrition[25]; see Figure 11.

[25] Of course, the willingness and ability of states to convert economic resources into reductions in hunger is not the only explanation for the divergences between actual and predicted GHI scores. Inevitable errors in the data and random deviations can also cause these divergences; as such, the significance of minor deviations should not be overstated.

Figure 10: Actual and predicted GHI scores plotted against Gross National Income per capita



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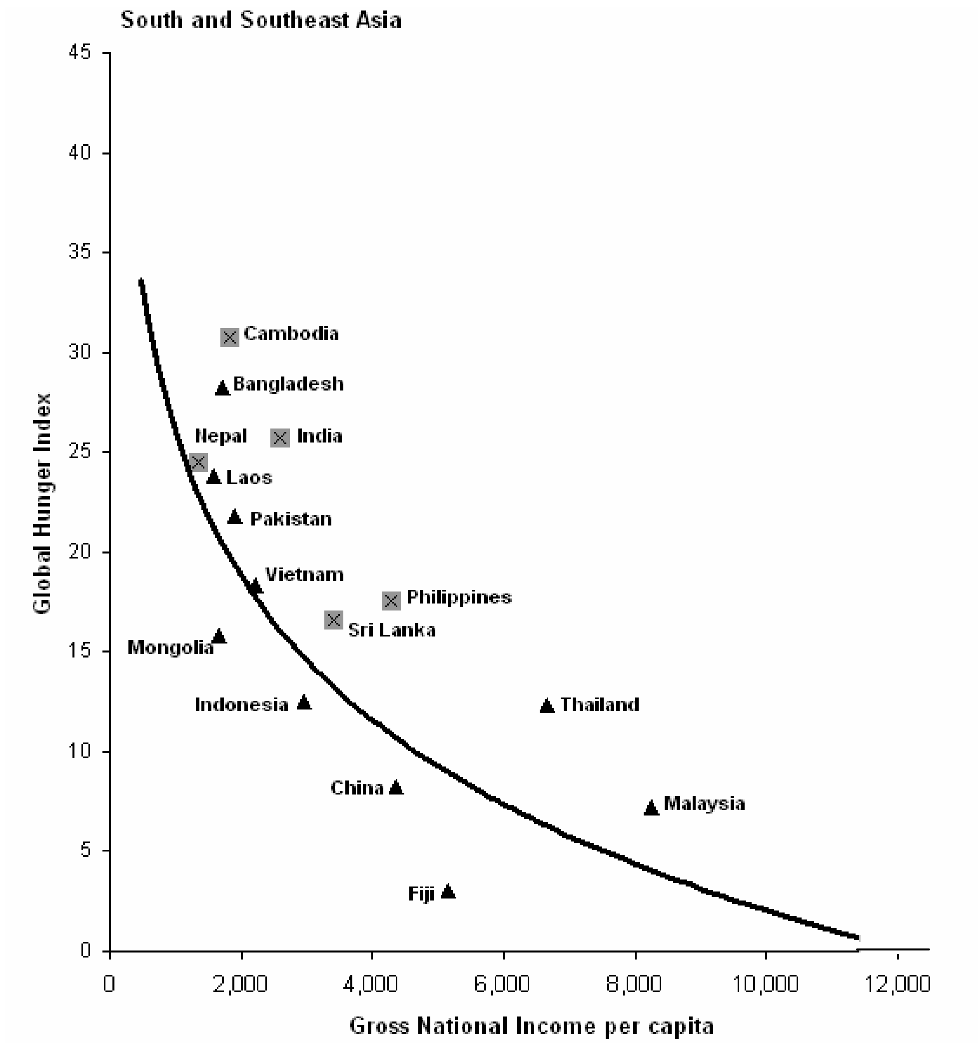

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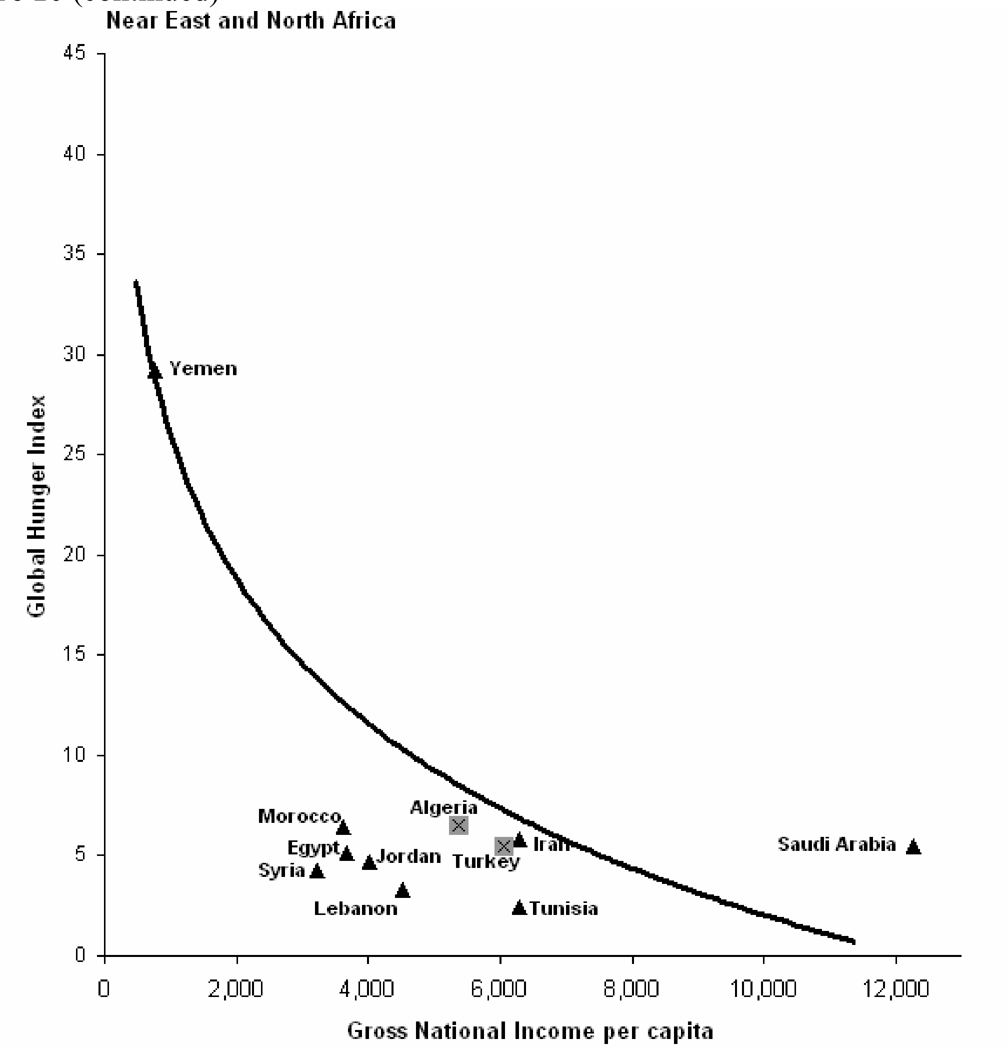

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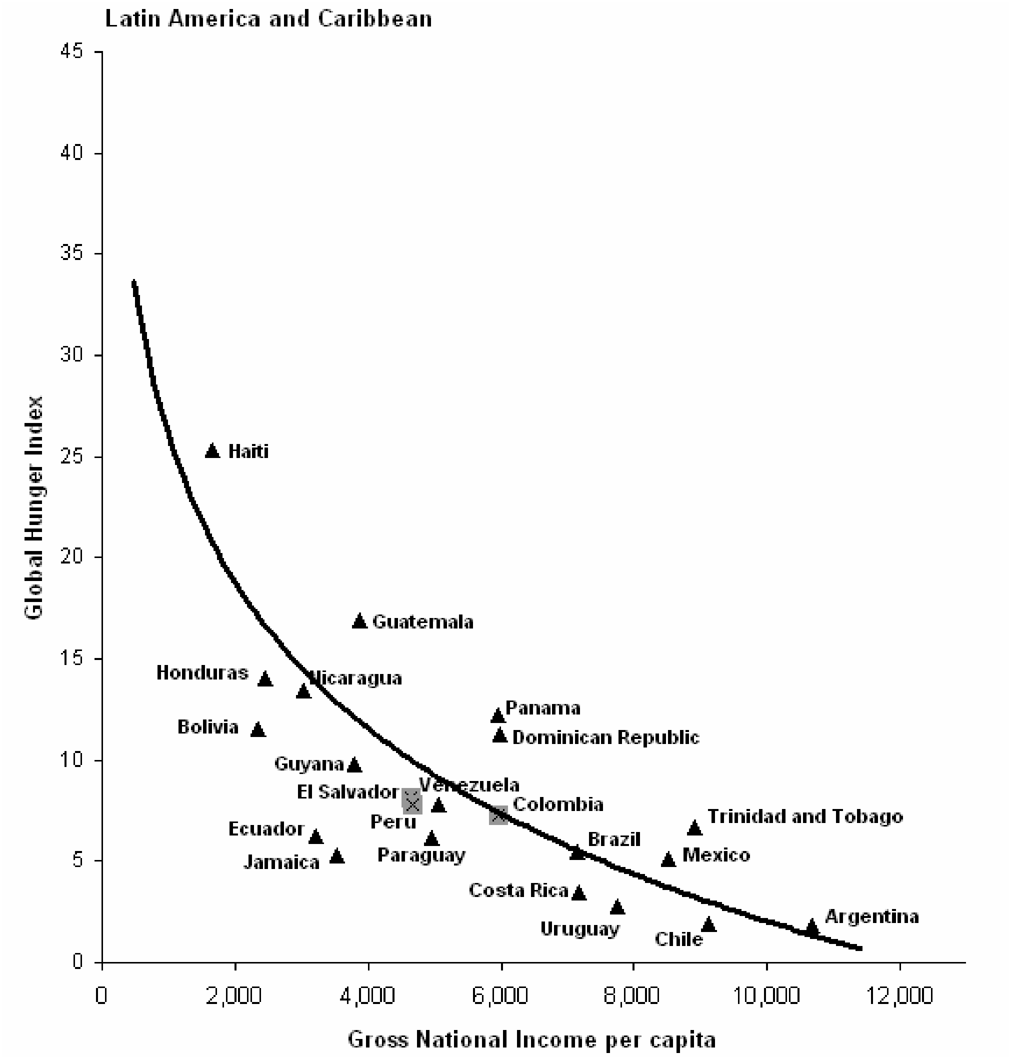

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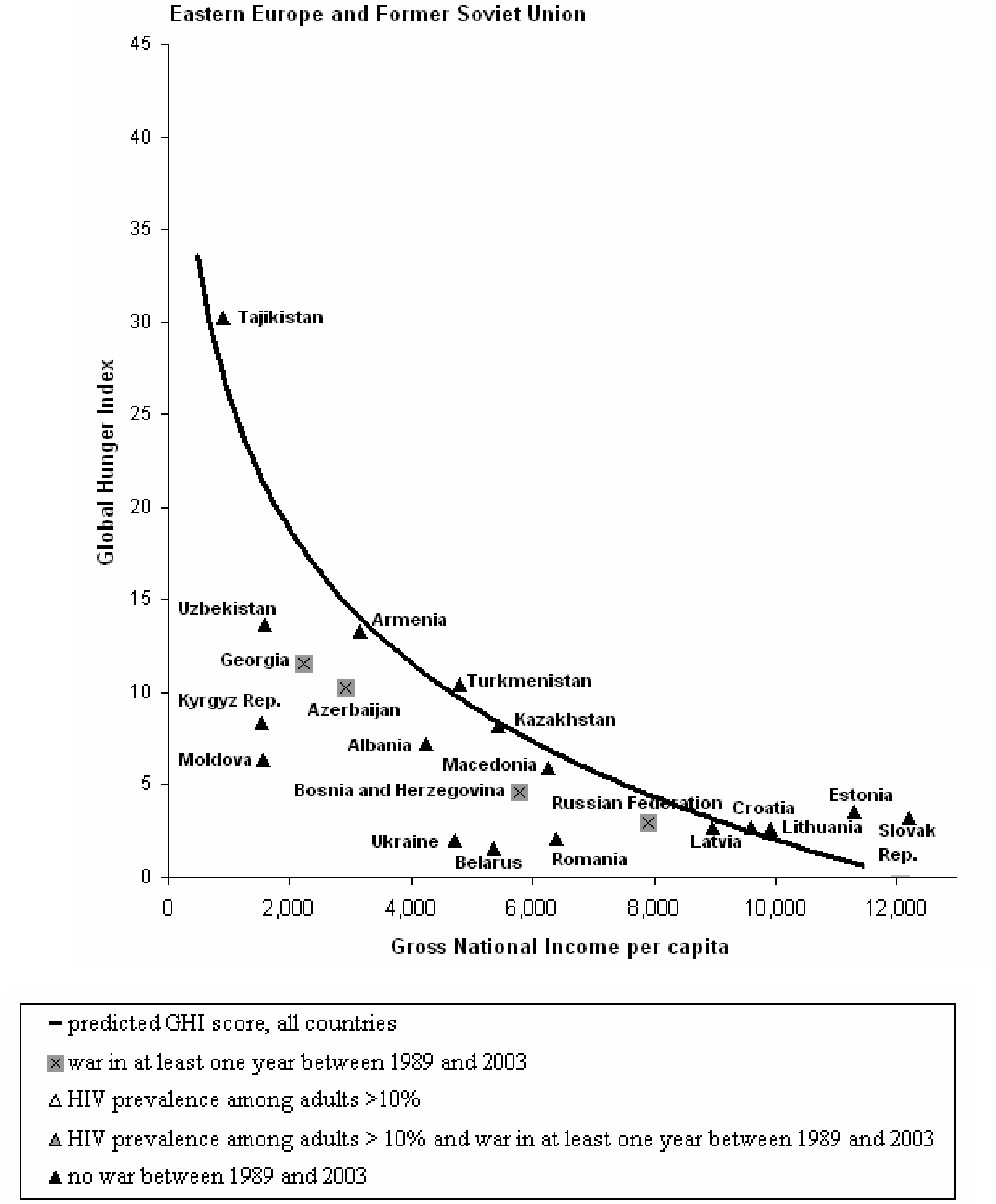
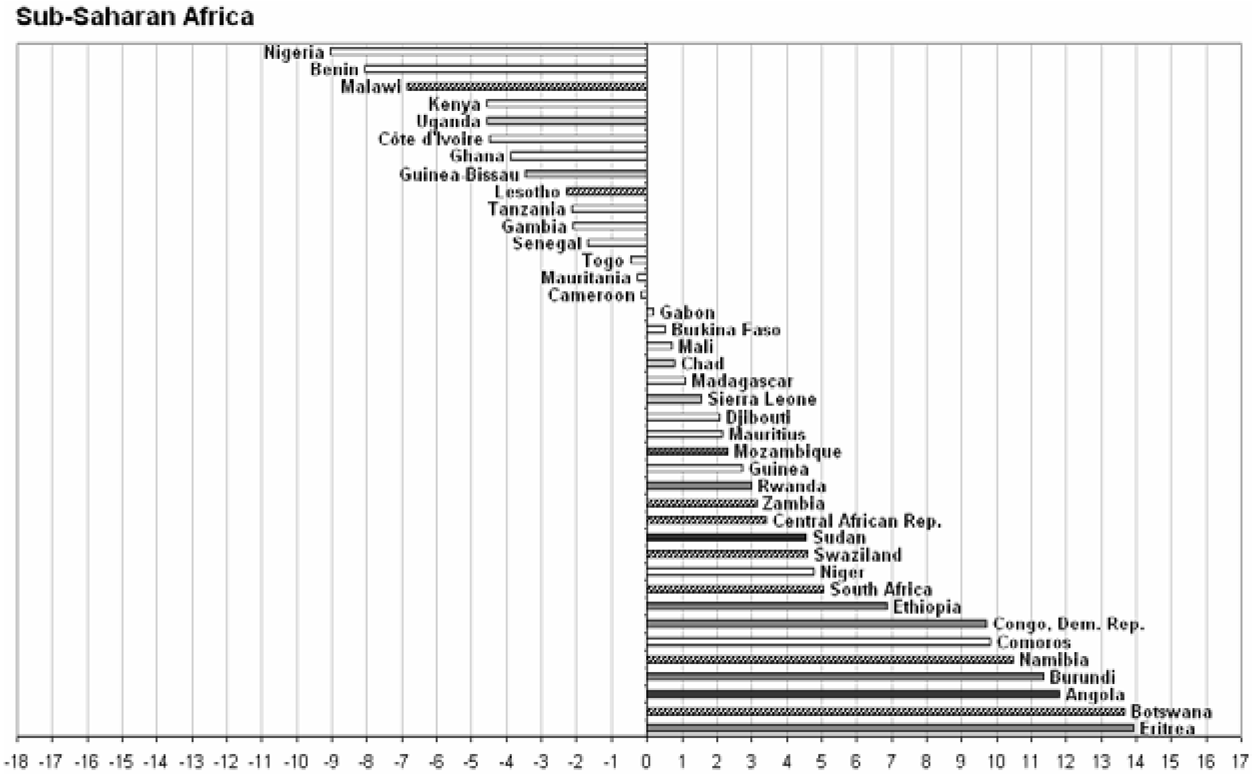
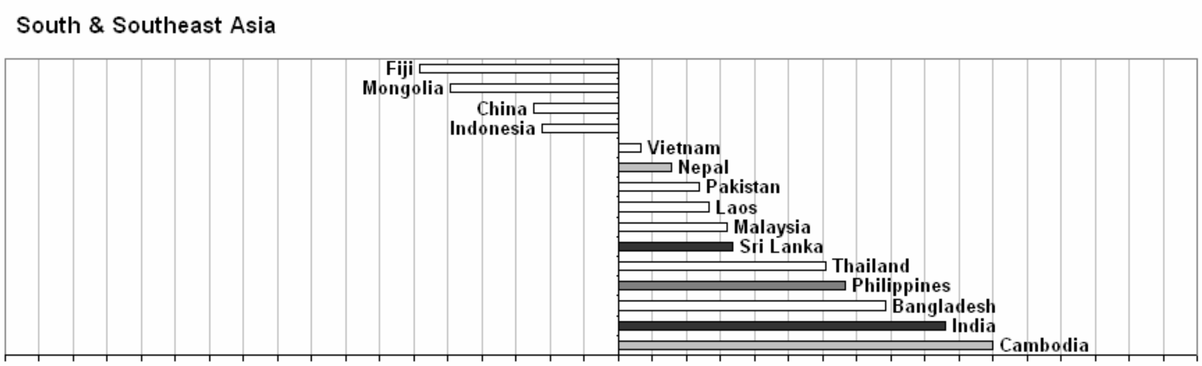


Source: Author's presentation, using GHI 2003 (and GHI 1997 for Costa Rica and Paraguay), data on GNI per capita (2001-2003 average, and 1995-97 average for Costa Rica and Paraguay) from World Bank 2005, data on HIV prevalence in 2003 from WHO/UNAIDS 2006, and information on wars from UCDP 2006; for the data sources of the GHI, see Table 1 in Box 1 of Chapter 2.

Notes: GNI per capita is based on purchasing power parity and expressed in constant 2000 international dollars. In Sub-Saharan Africa, not all countries are labeled. HIV prevalence rates greater than 10 percent among adults are only observed in Sub-Saharan Africa.

Figure 11: Differences between actual and predicted Global Hunger Index scores





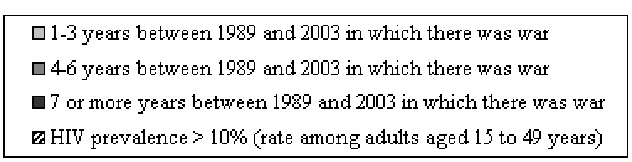


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Figure 11 (continued)

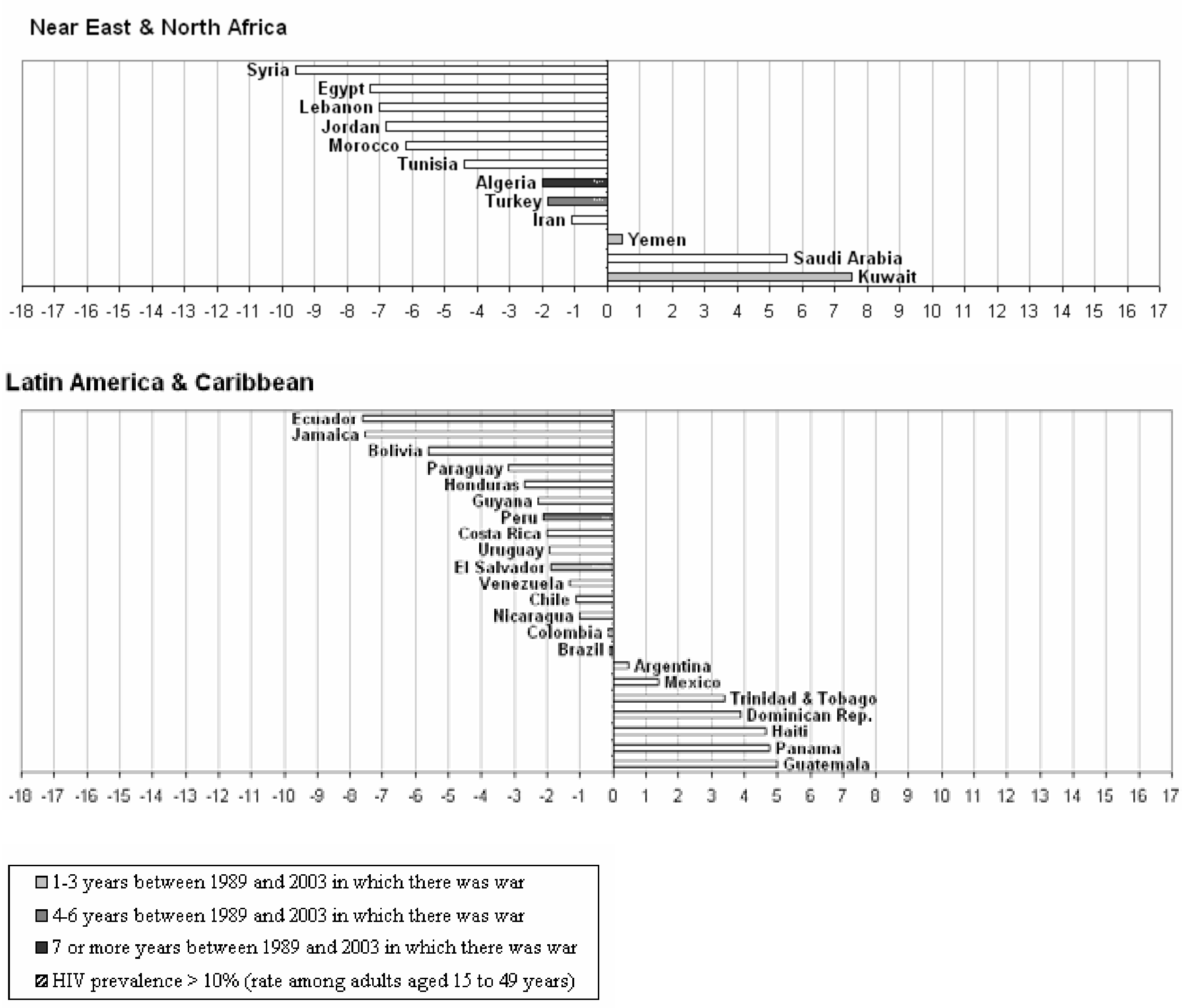

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Figure 11 (continued)

Source: Author's presentation; see Figure 10 and Table 1 in Box 1 of Chapter 2 for the data sources.

Notes: Positive values show that the situation is worse than expected when comparing to the Gross National Income per capita (GHI scores are higher than predicted). Negative values show that the situation is better than expected when comparing to the Gross National Income per capita (the GHI is lower than predicted). HIV prevalence rates greater than 10 percent among adults are only observed in Sub-Saharan Africa.

In Sub-Saharan Africa, quite a large number of countries have considerably higher GHI scores than would be expected according to their GNI per capita—this applies in particular to the Southern African countries Namibia, Angola, and Botswana; but also to Burundi, Comoros, Eritrea, and Ethiopia in East Africa and to the Democratic Republic of Congo. The political instability of the Comoros and the consequences of the wars in Angola, Burundi, Eritrea, Ethiopia, and the Democratic Republic of Congo were already discussed as causes of hunger in Chapter 3.

However, the reasons for the relatively bad performance in the middle-income countries Namibia and Botswana are different, since they were not involved in armed conflicts (UCDP 2006; CIA 2006). In these countries, high income inequality and high

HIV infection rates (almost 20 percent in Namibia and 24 percent in Botswana according to UNAIDS/WHO 2006) are obstacles to achieving food security and reducing child malnutrition and child mortality more effectively. The Gini coefficients for Namibia and Botswana, which indicate inequality of income distribution, are among the highest in the world: 0.71 and 0.63, respectively, in 1993 (World Bank 2005).

As a result of diamond mining (which accounts for about one-third of GDP), tourism, and sound investment strategies, Botswana has achieved impressive economic growth rates since independence in 1966 and has transformed itself from one of the poorest countries in the world to a middle-income country (CIA 2006). Yet, the poverty rate has remained high, because in contrast to countries with broad-based agricultural growth, large parts of the population were not able to benefit equitably from increasing national wealth. Consequently, 35 percent of the population in Botswana subsisted on less than one dollar a day in 1993, despite a Gross National Income per capita of about 5,700 international dollars per year (World Bank 2005).[26] [27]

The situation is similar in Namibia: the country's economy depends heavily on the extraction and processing of minerals for export, including diamonds. The mining sector accounts for 20 percent of GDP, but employs only 3 percent of the population. About half of Namibia's population depends on subsistence agriculture for its livelihood, and the country has to import about 50 percent of its cereal requirements. Food shortages are a major problem in rural areas in drought years (CIA 2006).

In contrast to the above-mentioned Sub-Saharan African countries, the GHI in Nigeria (a country that seems to have rather weak agricultural statistics) and Benin in

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[26] For comparison, the poverty rates in countries like Colombia, Romania, and Turkey were only about 2-3 percent at slightly lower levels of GNI per capita (between 5,300 and 5,600 international dollars) in the first half of the 1990s. In Thailand, GNI per capita was about 5,000 international dollars in 1992 and the poverty rate at one dollar a day only 6 percent (World Bank 2005).

[27] While the data on GNI per capita that are used here are in constant 2000 international dollars (taking into account purchasing power parity), the poverty rate is based on constant 1993 international dollars. To show the discrepancy between GNI per capita for Botswana and the income level of the poor more accurately, the former figure can be recalculated: GNI per capita per year for 1993 was about 5,000 in constant 1993 dollars, whereas about one-third of the population lived on less than 400 dollars per year (365 days times the poverty line threshold of 1.08 dollars equals 394 dollars).

West Africa and Malawi in East Africa indicates less hunger than expected according to GNI per capita. Similar to Ghana, the agricultural sector has been a driving force in Benin in the last decades: the yields of the most important staple foods doubled from 1970 to 1997, the area under cultivation expanded, and dietary energy supply per capita rose considerably by about 30 percent (data were taken from FAO 1999b).

In Asia, hunger is greater than predicted from GNI per capita in Cambodia, India, and Bangladesh, and lower in the Fiji Islands and Mongolia. Cambodia still suffers from the consequences of armed conflict and from lack of education and basic infrastructure (CIA 2006). While the long-lasting war was ended in 1989, the conflict continued at an intermediate level until 1998 (UCDP 2006). In fact, 1999 was the first full year of peace after 30 years of fighting, and the country's long-term economic development remains a daunting challenge (CIA 2006). In India and Bangladesh, high rates of child malnutrition are the main reason for high GHI scores relative to GNI per capita. The low status and lack of knowledge of women in South Asian countries are important determinants of the high prevalence of underweight children in this region (Smith et al. 2003; Ramalingaswami, Jonsson, and Rohde 1996; Smith and Haddad 2000).

In Bangladesh, adverse food habits also play a role: the conviction that women should eat less during pregnancy (Bangladesh 1997) is especially likely to contribute to the very high prevalence of low birth weight of 30 percent (UNS SCN 2004). Infants with low birth weight may never catch up the anthropometric shortfall at the very beginning of their lives (Ramalingaswami, Jonsson, and Rohde 1996). In addition, there has been no scope for expanding the area under cultivation in Bangladesh due to the country's extremely high population density. Cereal yields have nearly doubled since 1970, but the growth of food supply could not outpace population growth (Ahmed and Haggblade 2000).

In the Near East and North Africa, the majority of countries performed well as compared to their level of economic development, particularly Egypt and Syria. This can be partly attributed to the relatively equal income distribution in the countries of this region (the Gini coefficients are in the range of 0.33 to 0.43; compare World Bank 2005).

Furthermore, Egypt massively subsidizes basic foods like bread, sugar, and cooking oil (Ahmed et al. 2001). While this food subsidy program has surely helped the poorest to meet their dietary energy needs, its focus on energy-dense, nutrient-poor foods has fostered overconsumption of dietary energy among the population, with widespread overweight and obesity as a negative result (Asfaw 2006).

In Latin America and the Caribbean, Ecuador and Jamaica can be considered outliers with relatively low GHI scores; and Panama, Guatemala, and Haiti, outliers with relatively high GHI scores. Whereas income distribution is relatively equal in Jamaica, with a Gini coefficient of 0.38, it is much more skewed in Panama and Guatemala, with Gini coefficients of 0.56 and 0.60, respectively (World Bank 2005).

Haiti is the poorest country in the Western hemisphere and has a long history of political crises, violence, and bad governance by an irresponsible elite that has enriched itself instead of serving the people (IMF 1999; Gibbons 1999). High population density, extreme poverty, and inadequate farming practices led to large-scale deforestation and soil erosion, and together with inadequate pricing policies of the government, these factors have depressed agricultural production and food availability (Icart and Trapp 1999). Educational indicators and the quality and outreach of public services are poor compared to other low-income countries (IMF 1999; World Bank 2005).

For several countries in Eastern Europe and the Former Soviet Union, the GHI is amazingly low, given their GNI per capita (examples are Moldova, the Kyrgyz Republic, Ukraine, and Uzbekistan).[28] The economic situation in many transition countries deteriorated after the breakdown of communism, but high levels of education, the existing infrastructure, past investments in health care systems, and home-gardening on private plots helped to prevent large rises in child malnutrition and child mortality (Wiesmann 2004; Sedik and Wiesmann 2005). While income inequality increased during the economic transition, it is still low in most countries with a socialist legacy, with Gini

[28] However, the accuracy of national account statistics for these countries may be questioned.

coefficients ranging from 0.27 to 0.37 (World Bank 2005). Low-income inequality also contributes to favorably low GHI scores compared to GNI per capita.

The above findings raise the question about other determinants of hunger besides the availability of economic resources at the national level. Countries' participation in armed conflicts has already been mentioned in Section 3 as one of the causes of hunger and will be explored next.

Warfare

There are many reasons why warfare may harm food security and nutrition disproportionately, even beyond its immediate economic impact. Messer, Cohen, and Marchione (2001) state: "Combatants frequently use hunger as a weapon: they use siege to cut off food supplies and productive capacities, starve opposing populations into submission, and hijack food aid intended for civilians." Large production shortfalls in agriculture arise from the disruption of markets and the destruction of crops, livestock, roads, and land, from the shortage of vital inputs like fertilizer and machinery, and a lack of economic incentives for farmers in times of war (Messer, Cohen, and Marchione 2001; Guiton 2001; Rwelamira and Kleynhans 1996). Losses to the agricultural labor force result from killings, evictions, and recruitment of the most able-bodied. Young men hide during the day for fear of forced recruitment instead of working on the farms (reported by Feldbrügge 2000 for Angola).

When people are compelled to leave their homes, they are cut off from their usual food supplies and are often hard to reach by emergency operations. Besides war-related dislocation, relative price changes, unemployment, and income losses keep people from demanding food in the market (Feldbrügge 2000). The detrimental effects of violent conflict on food security do not always show up in GNI figures, because, incidentally, a booming war economy, fueled by international trade in diamonds or oil, is able to disguise agricultural decline and the consequence of a desperate food supply situation for the population (Wiesmann 2004).[29]

Regarding caring capacity as an important determinant of child nutrition and survival, it is affected by massive population displacements in violent conflicts, which often go along with household dissolution, community disintegration and breakdown of social networks. Moreover, killings deprive children of their caretakers, and together with other human rights violations, they cause considerable psychological distress. Good mental health and lack of stress have been mentioned as important resources for adequate caregiving (Engle, Menon, and Haddad 1999).[30] Loss of human capital and caring capacity is also a frequent outcome of lacking education and training in times of war. Schools are destroyed, and the education of a whole generation is probably neglected, especially in long-lasting civil wars (Rwelamira and Kleynhans 1996).

Additionally, health environments—the third main determinant of child nutrition and survival—are likely to worsen in multiple ways. Deliberate destruction of health care facilities has, for example, been reported in Liberia, Mozambique, and Sierra Leone (Green 1994). Breakdown of the health care system due to lack of public funding, medical supplies, and personnel can be another disastrous consequence of conflict (Criel 1998). Furthermore, refugees and internally displaced persons, in particular, lack basic necessities. In refugee camps, they are frequently subject to overcrowding, poor sanitary conditions, and inadequate food supplies.[31] Together with large population movements

[29] Yet, even agricultural products can serve as a source of revenue for war economies; see Messer and Cohen 2006 for examples of cotton and coffee exports triggering conflict.

[30] Recent studies point to severe psychiatric disorders in war refugees: a study in Cambodian refugees revealed that 68 percent were suffering from acute clinical depression, and 37 percent from post-traumatic stress disorder (Mollica 2000).

[31] Even if dietary energy content of food rations is sufficient, essential micronutrients are often lacking. Outbreaks of micronutrient deficiency diseases that are rarely observed in populations in their normal environment have been frequently reported from refugee camps. Baquet and van Herp 2000, for example, give an account of a pellagra epidemic in Internally Displaced People depending on World Food Programme rations around Kuito, Angola, in 1999 and 2000. They also refer to a large pellagra outbreak among Mozambican refugees in Malawi in 1990. They note that in recent years, outbreaks of pellagra have only occurred in emergency affected populations. Pellagra can be fatal and is caused by a deficiency of niacin and/or the amino acid tryptophan in the diet.

and the impairment of the health care system, the living conditions in camps facilitate the spread of infectious diseases, including HIV infection (see Bucagu 2000 for a report on Rwanda). In February 2004, over 45 million people in conflict and post-conflict countries were in need of food and other emergency humanitarian assistance (according to figures released by UN agencies), and more than 80 percent of the population affected lived in Sub-Saharan Africa (Messer and Cohen 2004).

The notion that wars have a direct negative impact on food security and nutrition apart from their effect on the economy is supported by a look at the shaded bars in Figure 11: conflict countries do worse than expected from their GNI per capita more frequently than nonconflict countries. The rough classification by the number of war years experienced between 1989 and 2003 does not properly reflect the severity of the conflict, its geographical scale, or the proportion of the population affected. Yet, especially in Sub-Saharan Africa, most of the large outliers with comparatively high GHI scores were ravaged by long-lasting wars. Bad governance associated with the armed conflicts in these countries presumably contributed to the unfavorable outcomes depicted in Figure 11.

Controlling for the variation of GNI per capita, the GHI is higher by 3.9 points in countries that were involved in warfare between 1989 and 2003 than in non-war countries (that is, the GHI is about 22 percent higher for war countries than it is for non-war countries with comparable levels of economic development).[32] A higher proportion of undernourished and higher prevalence of underweight in children in war countries (+ 6.9 and + 4.4 percentage points, respectively, again controlling for the variation in GNI per capita) are responsible for this result, while no significant difference is observed with regard to the under-five mortality rate. (See Appendix D Table 20 for the details of these regressions.)

[32] This result was obtained in a regression analysis including the logarithm of GNI per capita and is significant. For a more extensive econometric analysis of the association of war and war duration with food security and nutrition, see Wiesmann (2004).

The full impact of wars on hunger is probably not reflected in these regression results, because conflict may not only worsen food insecurity relative to GNI per capita, but also precipitate economic decline. Moreover, food insecurity is not only an effect, but also a potential cause of conflict. Given a set of unfavorable political, cultural, and economic conditions, food insecurity and famine can trigger civil wars (Messer, Cohen, and Marchione 2001; Messer and Cohen 2006). Countries may embark on a downward spiral of increasing impoverishment, hunger, and violence, leading to complex humanitarian emergencies. As a result, wider security crises can occur and entire regions can be destabilized.

But spill-over effects do not necessarily stop at the regional level: countries in danger of collapse due to conflict and poverty are believed to be fertile ground for terrorism, crime, and disease, with possible negative consequences for global security. Therefore, in a recent report, the World Bank's Independent Evaluation Group called for more effective assistance to so-called "fragile states," which are low-income countries with weak policies, institutions, and governance (IEG 2006). Examples are Somalia, a country without a central government that could not be included in the GHI ranking due to the absence of reliable statistical information, and Afghanistan, for which the lack of data also prevented GHI calculation. The 15 fragile states in 2003 are mostly concentrated in the bottom third of the GHI ranking. Half of the 12 countries that did worst according to GHI 2003 were also classified as "fragile states" in 2003: Tajikistan, Liberia, Angola, Sierra Leone, Democratic Republic of Congo, and Burundi. Interestingly, two other countries in the group with a GHI 2003 greater than 30—Cambodia and Comoros—had become fragile states by 2005 (IEG 2006).

Like armed conflict, the spread of HIV and AIDS affects food security in multiple ways and can in turn be aggravated by high levels of food insecurity. The role of the AIDS pandemic as a cause of hunger will be discussed in the following section.

HIV and AIDS

AIDS affects agricultural production and household food security: premature illness and death of prime-age adults, who are the most productive members of society, erodes livelihoods and fractures intergenerational knowledge transfer. Households experience financial stress as expenditures for health care and funerals increase, and as credit becomes harder to access. Labor losses affect the ability to farm and to maintain common property resources, and assets are being sold to raise cash (Gillespie and Kadiyala 2005).

Moreover, HIV/AIDS and hunger can become intertwined in a vicious cycle. While AIDS exacerbates hunger, food insecurity may heighten exposure to HIV (e.g., when men migrate to look for work or women engage in transactional sex to provide for their families) and the susceptibility to infection. For example, a young woman's poverty may be deepened by a parent's illness or death from AIDS. In order to feed her siblings, she may have few options other than selling her body, thereby drastically increasing her own risk of becoming HIV-positive. If her immune system is weakened by malnutrition, this further raises the risk of infection (Gillespie, Kisamba-Mugerwa, and Loevinsohn 2004). In addition, people living with HIV who are malnourished are more vulnerable to severe opportunistic infections and more likely to die soon (Gillespie 2006).

In Sub-Saharan Africa alone, AIDS has orphaned more than 12 million children (UNAIDS/WHO 2006). Given the death and disease toll of AIDS in some countries, traditional kinship networks are stressed to the limits of their capacity to provide care for orphans and the sick. Women and girls are hit hardest due to their greater social and biological vulnerability to infection and their role as caretakers for sick family members, with negative consequences for childcare (FAO 2001, Wilson 2000). With the mother-to-child transmission rate being between 25 and 35 percent, HIV is contributing substantially to increasing infant and child mortality rates in the Sub-Saharan countries that are worst affected by HIV and AIDS (UNAIDS/WHO 2006; Gillespie 2006).

In 2003, the highest HIV prevalence rates among adults were found in Botswana and Swaziland (24 and 32 percent, respectively). Prevalence rates greater than 5 percent are limited to Sub-Saharan African countries (UNAIDS/WHO 2006). In the chart for Sub-Saharan Africa in Figure 11, the bars for countries with HIV prevalence rates higher than 10 percent are marked by the striped bars. Except for Comoros and Niger, which were already briefly discussed in Chapter 3, all Sub-Saharan African countries with GHI scores that exceed the predicted GHI score by more than 3 points were either engaged in warfare between 1989 and 2003 or had HIV prevalence rates greater than 10 percent in 2003.

Controlling for the variation in GNI per capita, the Global Hunger Index is 3.9 points higher in countries with an HIV prevalence of greater than 10 percent than it is in countries with lower prevalence rates (that is, the GHI is about 23 percent higher for countries with prevalence rates over 10 percent than it is for countries with lower prevalence rates and comparable levels of economic development). This can be attributed to concurrent significant differences in the percentage of undernourished and the under-five mortality rate (+ 7.1 and + 4.0 percentage points, respectively). (See Appendix D Table 21 for the details of these regressions.)

This result underscores that the manner in which the AIDS pandemic is confronted is crucial for protecting food security in the affected countries. Without combating HIV and AIDS effectively, the fight against hunger cannot be won in the countries that are hit hardest by the epidemic. A multisectoral approach bringing together agriculture, nutrition, and health is needed to achieve breakthroughs in the fight against HIV/AIDS and to reduce hunger and poverty (Gillespie 2006).

This multisectoral approach is in line with the concept of the GHI that suggests targeting the three dimensions—household food security, (child) nutrition, and health—simultaneously. Using the GHI as a measurement tool could raise awareness for the synergies of interventions in these three areas in the context of HIV and AIDS as well as with regard to other challenges to food security and nutrition. The vital linkages between agriculture and health are increasingly recognized and call for a closer integration of research and decisionmaking in these sectors (Hawkes and Ruel 2006).

5. Conclusions

The Global Hunger Index (GHI) can serve as a tool for advocacy to mobilize political will in the fight against hunger and undernutrition, to foster a sense of urgency among countries, and to promote good policies. The GHI includes three equally weighted indicators: the proportion of undernourished in the total population as estimated by FAO, the prevalence of underweight in children under five, and the under-five mortality rate (in percent). The GHI has properties that make it able to reflect relevant serious nutritional problems, such as micronutrient deficiencies.

The GHI is calculated for the years 1981, 1992, 1997, and 2003. The latest GHI score is used for ranking 97 developing countries and 22 countries in transition. The GHI findings show that the hot spots of hunger and undernutrition are in South Asia and Sub-Saharan Africa. Positive trends prevail in South and Southeast Asia, where the Green Revolution boosted food supplies and acted as an engine for economic growth. Investments in the social sector and infrastructure further explain the positive development in the Asian region.

In contrast, the trends are mixed for Sub-Saharan African countries, where there has been less progress in rural growth. While some countries in the region, nevertheless, show a good track record, wars and bad governance produced detrimental outcomes in other countries. Moreover, warfare was frequently accompanied by economic mismanagement such as excessive price controls and barriers to internal trade and market development that were set up by the state. Yet, some countries that were plagued by particularly destructive armed conflicts have become examples of successful rehabilitation and reconstruction after the end of the fighting and the implementation of economic reforms.

Further analysis of the GHI in relation to GNI per capita shows that the availability of economic resources at the national level determines the extent of hunger and undernutrition to a large extent. While economic growth is central for promoting food security, there remains considerable scope for policies to relieve hunger and undernutrition that is independent of its pace. Armed conflicts seem to aggravate hunger even apart from their impact on macroeconomic performance. Violent conflicts have long-term negative effects on the GHI, and protracted wars are more destructive than short episodes of fighting (Wiesmann 2004). More attention should, therefore, be given to conflict prevention and resolution as well as to rehabilitation measures in the field of agriculture, nutrition, and health after peace has been restored. Development projects and humanitarian assistance should be conflict-sensitive, in order not to unintentionally exacerbate the root causes of the conflict, such as social inequities between ethnic groups.

A climate of peace and security can also free public resources that may have been diverted to military spending in the past for necessary investments in the agricultural, health, and education sectors. Agriculture can play a key role in fostering broad-based economic development and in improving food supply, especially in low-income countries. In these countries, the poor participate much more in growth in the agricultural sector than in the nonagricultural sector, resulting in a much larger poverty reduction impact of agriculture (Christiaensen, Demery, and Kühl 2006). Therefore, more resources should be directed to agricultural research and extension services in order to maintain and enhance agricultural productivity.

For Sub-Saharan Africa, higher investments in rural infrastructure, water and land management, and communications and marketing are also of key importance to feeding a growing population (Rosegrant et al. 2005) (see also Simler et al. 2004 on Mozambique). A study by Dercon et al. (2006) in 15 villages in rural Ethiopia shows that public investments in road quality and access to agricultural extension services lead to faster consumption growth and lower poverty rates.

Whereas improved provision of health and education services raises farmers' productivity, it also has a direct effect on child malnutrition and child mortality, two of the three components of the GHI. Encouraging the utilization of health care services has proven more successful than merely expanding physical access to facilities (Criel 1998). This strategy often requires educating the population about the benefits of health care and setting incentives to use the services offered. Conditional cash transfer programs that make the payment of transfers contingent on the utilization of preventive health-care services have proven suitable for this purpose. These programs have also been successfully employed to raise school enrollment rates, particularly among girls (Maluccio and Flores 2005; Skoufias 2005).

Creating educational opportunities for females is especially important in regions like South Asia, where women's low status and lack of knowledge on adequate caring and feeding practices contribute to high child malnutrition rates. Combating the AIDS pandemic and its negative impact on food security and nutrition requires social protection as well as interventions in the fields of agriculture, public health, and nutrition (Gillespie 2006).

In conclusion, the fight against hunger remains very much a task of public action by both government and civil society organizations. Well-designed, effective food- and nutrition-oriented policies contribute directly to people's welfare, but do so indirectly also by raising their capacity for work and their incomes. International support for investment in the agriculture, food, health, and education sectors is needed and can produce high returns, if not counteracted by bad governance and military conflict.

It is hoped that the GHI will strengthen the attention to the hunger problem and make both developing and developed countries, national and international players, more accountable for their commitments and will help to speed up urgently needed progress in the fight against hunger.

APPENDICES

APPENDIX A

Measurement Concept and Requirements for International Indices

Given their multifaceted nature, food security and nutrition security—or the absence thereof (i.e., "hunger" in a broad sense)—can be considered abstract variables that are not directly measurable. This may apply to nutrition security to an even greater extent than to food security (compare the definition in footnote 5):

> A person is considered nutrition secure when she or he has a nutritionally adequate diet and the food consumed is biologically utilized such that adequate performance is maintained in growth, resisting or recovering from disease, pregnancy, lactation and physical work (Frankenberger, Oshaug, and Smith 1997, 1).

It is evident that no single indicator exists that could capture all aspects of food security or nutrition security.

An index such as the Human Development Index can be described as a measurement concept to portray an abstract variable that is not directly observable (Nübler 1995). The measurement concept is composed of three conceptual levels:

1. an unobservable abstract variable that is not accessible to direct measurement and that is the "ultimate criterion of interest" (other examples than food and nutrition security are human development or health);
2. dimensions defining the abstract variable—they index the degree of success in terms of the abstract variable, but are not directly observable either;
3. empirical variables that are observable and quantifiable and that can indicate the abstract variable that is to be measured, given a theoretical relationship formulated via the dimensions (Nübler 1995).

The interrelationship of the dimensions should be specified by a conceptual framework (Ryten 2000). Ideally, the index should be constructed in such a way that it is useful for the policy process and statistically sound (see the list of desirable properties in

Table 3 below). In practice, data availability may be limiting, and there are also trade-offs between some of the technical requirements. For example, high correlations among the components make an index more robust against measurement error and the modification of weighting factors, but they also entail a certain level of redundancy as compared to its components. Likewise, an index that is stable against random fluctuations may also be less sensitive to policy-relevant changes.

Table 3: List of desirable properties of international indices

Requirements for the policy process	Technical requirements
• policy-relevant • sensitive to inequality • adequate ("answering the right questions") • communicable to policymakers and the general public • replicable • backed by theory/scientific concept • available for a large number of countries • suitable for annual (or at least biannual) updates	• comparable over time • comparable across countries • based on valid methods of measurement • nonredundant (information not already captured in components/simpler indicators) • able to differentiate among countries • robust against measurement error and moderate changes in aggregation function • stable against random fluctuations • sensitive to changes over time

Source: Author's presentation, based on Nübler 1995, Ryten 2000, and Szilágyi 2000.

The desirable properties listed in Table 3 were discussed in detail for an international Nutrition Index, the predecessor of the Global Hunger Index, which was based on the same set of indicators and on almost identical weights for aggregation (see Wiesmann 2004). Some of the technical requirements are referred to in the following sections on the choice of indicators, the weighting and standardization of index components, and the question of the redundancy of the GHI.

Technical Notes on the Choice of Indicators

Based on the conceptual framework in Chapter 2 of the main text, three dimensions of hunger are defined and three indicators are selected to represent them: the proportion of undernourished (as estimated by FAO), the prevalence of underweight in children, and the under-five mortality rate. The following section explains in some more detail why these indicators are preferred to related measures that might also be suitable for capturing one of the index dimensions.

The Proportion of Undernourished

In the absence of precise and broadly available international data on the food consumption of households and individuals, the proportion of undernourished is preferred to dietary energy supply per capita (DES) to reflect the dimension of the adequacy of dietary energy intake. Though the proportion of undernourished as estimated by FAO may not give due consideration to the interhousehold inequality of dietary energy intakes (Svedberg 1999; Smith 1998), dietary energy supply per capita is even less likely to do so. Moreover, there is no fixed upper boundary of dietary energy supply per capita that guarantees freedom from hunger for the total population: for this reason, arbitrary limit setting would be unavoidable if dietary energy supply per capita was used for index calculation.

The Prevalence of Underweight in Children

Besides considering children's particular vulnerability to undernutrition, the use of anthropometric data on children's nutritional status is also justified from a methodological point of view: these data are comparable across countries. In contrast to the body size of adults, the growth potential of children under five does not differ significantly by ethnic origin (WHO Multicentre Growth Reference Study Group/de Onis 2006). Moreover, international data about the nutritional status of adults are not yet broadly available, whereas anthropometric data referring to children have been collected by WHO in a large, regularly updated database (WHO 2006).

Three anthropometric indicators for children are usually of interest in nutrition surveys: the prevalence of low height-for-age (stunting), low weight-for-height (wasting), and low weight-for-age (underweight) (WHO 1997). Wasting is not well suited for use as a single anthropometric indicator in the GHI. The prevalence of wasting tends to be much lower than the prevalence of stunting and underweight, which means that the weight-for-height indicator is not able to capture the true magnitude of the problem of child malnutrition (Wiesmann 2004).

Two examples may illustrate that wasting does not adequately answer the question about the true extent of child malnutrition. A nutrition survey of preschoolers in Guatemala in 2002 revealed that 1.6 percent of the children were wasted, 22.7 percent were underweight, and 49.3 percent were stunted (WHO 2006). According to the wasting indicator, undernutrition appears to be a minor problem in this country. Yet, since wasting reflects only acute undernutrition, it effectively conceals that about half of the children are affected by chronic malnutrition in Guatemala, as evidenced by the stunting rate. In contrast to wasting, stunting and also underweight (at least to some extent) are able to reflect the chronic aspect of child malnutrition. This also applies to the case of India, where 15.7 percent of children under three were wasted, 45.7 percent were underweight, and 44.9 percent were stunted in 1998-1999 (WHO 2006). Consequently, an indicator that exclusively provides information on acute undernutrition in children is not adequate for our purpose (because it does not answer the right questions—see the requirement for adequacy in Table 3).

Stunting in children basically follows the same trends as underweight (WHO 1997). However, growth faltering does not occur immediately when food and nutrition security worsen, but with a certain time lag. Therefore, the ability of this indicator to reflect changes fully and without delay may be questioned, since it does not indicate acute malnutrition. Thus, the anthropometric measure for underweight—low weight-for-age—is preferred to the other anthropometric indices because it encompasses both chronic and acute malnutrition. Among the three anthropometric measures, underweight is also the most characteristic indicator in a statistical sense, because it has the highest correlations with the other two indicators. The prevalence rates of stunting and wasting are only relatively weakly correlated. Underweight is also the indicator with the best data availability (limited data availability is an argument against the inclusion of all three child malnutrition indicators in the index) (Wiesmann 2004).

The Under-Five Mortality Rate

Food insecurity and undernutrition do not only affect the survival chances of children, but they also tend to raise adult mortality rates, especially during famines. Yet, when comparing across countries, mortality among adults varies to a larger extent according to factors that are not linked to nutrition (other lifestyle aspects, hazardous occupations, or active participation in wars). Therefore, child mortality is preferred as a proxy for premature deaths associated with malnutrition, although mortality data are also available for the population as a whole (Wiesmann 2004).

For both conceptual and statistical reasons, the under-five mortality rate is preferred to the infant mortality rate, which measures deaths per 1,000 live births before the age of one. The infant mortality rate cannot fully account for the effects of deteriorating nutritional status during the “weaning crisis” on mortality. Severe malnutrition occurs in almost all developing countries at the weaning age of about 6-24 months and is associated with poor feeding and health practices (Zeitlin 1988). In countries with low child mortality rates, about 90 percent of deaths in under-five-year-olds occur before the age of one, but only about 60 percent of deaths occur before the age of one in the countries with the highest child mortality levels (author’s calculation based on data from UNICEF 2005). Regarding the information contained in their rankings, the infant mortality rate and the under-five mortality rate are highly redundant, with rank correlation coefficients in large cross country samples close to unity (about 0.99). However, with a maximum of 166 per 1,000 live births (that is, 16.6 percent), and a minimum of 0.6 percent, the infant mortality rate covers a much smaller range than the under-five mortality rate with a minimum of 0.7 percent and a maximum of 28.4 percent (data from UNICEF 2005 for 2003 for countries for which Global Hunger Index scores were calculated). Therefore, using the infant mortality rate would exacerbate the problem of divergent ranges and standard deviations of the three index components (see Table 4 in the next section and the discussion on page 70ff).

Technical Notes on Weighting and Standardization of Index Components

The following section explains the rationale for weighting the three components of the Global Hunger Index (GHI) equally and for abstaining from a standardization of the partial indicators. It presents the results of a principal components analysis for the three indicators selected for the GHI, and examines the robustness of the index to changes in weights and to the use of standardization for the index components. A more comprehensive discussion on the transformation, standardization, weighting, and aggregation of indicators can be found in Wiesmann (2004).

For the calculation of descriptive statistics (see, for example, Table 4 below) and correlation coefficients in this section as well as the regressions shown in Appendix D, the data were not weighted by population size. This is because the countries, not the people, are the unit of analysis and the aim is to use the variation of the GHI and its components across countries to draw out the relationships between variables measured at the national level. In this analysis, each country is considered a single political entity to be compared to the others, regardless of population size. This approach avoids that large countries like India and China become the main drivers of the correlation and regression results. Consequently, the descriptive statistics should not be regarded as representing global levels or trends. Of course, the data were weighted by population size to calculate aggregate regional GHI scores: see the notes in Appendix C.

Table 4: Descriptive statistics for the GHI and its components

	Mean	Standard Deviation	Minimum	Maximum
Proportion of undernourished (in percent)	19.8	16.5	0.0	73.0
Prevalence of underweight in children (in percent)	17.1	13.3	0.5	48.3
Under-five mortality rate (in percent)	8.2	7.0	0.7	28.4
Global Hunger Index (GHI)	15.0	10.6	1.6	42.7

Source: Author's calculations; see Table 1 in Box 1 of Chapter 2 for the data sources.

Note: Number of cases: 119.

There is no unambiguous way to derive weights or choose the aggregation function for the purpose of index calculation. Implicit assumptions and value judgments play an important role in the selection of weights, which should be justified theoretically or supported by empirical findings (Nübler 1995). The manner of aggregation—that is, the functional form and the weights for indicators—should be selected from an easily understandable set and should be robust in the face of small changes (Ryten 2000). The simplest possibility is usually equal weighting or "natural averaging" of the partial indicators of the index. Principal components analysis (a special form of factor analysis that serves to condense information) is also frequently used in order to derive weights from an empirical basis. This approach is chosen in this study to explore options for weighting the GHI. (Since each dimension of the GHI is represented by only one variable, the application of a weighted principal components analysis, as suggested by De Silva, Thattil, and Gamini [2000] for deriving the weights of a composite index, is not necessary.)

The three index components are well-suited for a joint principal components analysis, as the statistics in Table 5 confirm. The correlations (Pearson's) between the variables are highly significant and in the range of medium to high. The Kaiser-Meyer-Olkin measure of sampling adequacy is 0.71 for the selected variables and therefore falls into the category that is usually classified as "middling" or "quite good." Measures of sampling adequacy for single variables that are given on the diagonal of the anti-image correlation matrix indicate that all three indicators are suitable for a common factor analysis. One factor was extracted that accounted for about 75 percent of variation. Factor scores obtained for the indicators were divided by their sum in order to normalize the sum of weights to one.

The weights derived from principal components analysis for the three indicators are so close to one-third that equal weighting is supported not only conceptually (because all three indicators represent important dimensions of hunger), but also empirically. The statistics in Table 5 are based on data from 116 countries with GHI 2003 and three countries with GHI 1997, including countries for which the author estimated the proportion of undernourished and underweight in children. In addition, different subsets of the total data set were subjected to principal components analysis, with estimates for the proportion of undernourished and for underweight in children included one time and excluded another time, and comprising data for several GHI reference years (1992, 1997, and 2003). Weights were found to be quite stable at about one-third for all three indicators. They ranged from 0.32 to 0.34 for the proportion of undernourished, from 0.31 to 0.33 for the prevalence of underweight in children, and from 0.33 to 0.36 for the under-five mortality rate.

Table 5: Results from principal components analysis

	Proportion of undernourished (percent)	**Children underweight (percent)**	**Under-five mortality (percent)**
Pearson's Correlation Coefficients			
Proportion of undernourished	1	-	-
Children underweight	0.57***	1	-
Under-five mortality rate	0.64***	0.65***	1
Anti-Image Correlation Matrix[a]			
Proportion of undernourished	0.74	-	-
Children underweight	-0.25	0.73	-
Under-five mortality rate	-0.44	-0.46	0.68
Factor statistics	**Eigenvalue**	**Percent of variance**	**Cumulated percentage**
Factor 1[b]	2.24	74.7	74.7
Factor 2	0.44	14.5	89.2
Factor 3	0.33	10.8	100.0
Final statistics of variables	**Communality**	**Factor score**	**Derived weight[c]**
Proportion of undernourished	0.72	0.85	0.33
Children underweight	0.73	0.85	0.33
Under-five mortality rate	0.79	0.89	0.34

Source: Author's calculations, see Table 1 in Box 1 of Chapter 2 for the data sources.

Notes: Number of cases: 119. *** Coefficients are significant at the 1 percent level. The anti-image correlation matrix is used to evaluate the suitability of a set of variables for factor analysis (Backhaus et al. 2000). The image of a variable is the component of a variable that can be predicted from the other variables in the set; the anti-image is the specific part of the variable that cannot be predicted (Guttman 1953). Because factor analysis presupposes the existence of common underlying factors for the selected variables, the anti-image of each variable should be small (Backhaus et al. 2000). The anti-image correlation matrix presents the negative anti-image correlations (negatives of the partial correlation coefficients between pairs of variables, having first controlled for the effects of all other variables) on the off-diagonal. In a good factor model, most of the off-diagonal elements will be small (Pett, Lackey, and Sullivan 2003). The measure of sampling adequacy for a variable is displayed on the diagonal of the anti-image correlation matrix, and is a summary of how small the partial correlations are relative to the ordinary correlations. Values greater than 0.8 can be considered commendable; values greater than 0.7, middling; and values greater than 0.6, mediocre. Values less than 0.5 require remedial action, either by deleting the offending variables or by including other variables related to the offenders (Kaiser 1970; Kaiser and Rice 1974; Cerny and Kaiser 1977). The same categorization applies to the overall measure of sampling adequacy for the correlation matrix, which is also called the Kaiser-Meyer-Olkin criterion (Backhaus et al. 2000).

[a] The Kaiser-Meyer-Olkin Measure of Sampling Adequacy is 0.714.

[b] Only Factor 1 was finally extracted by principal component analysis (criterion: eigenvalue > 1).

[c] Formula for derivation:

$$\text{Weight of variable } x = \frac{\text{Factor score of variable } x}{(\text{Sum of all factor scores})}.$$

While these results strongly suggest equal weighting, modified weights for the components are applied in the following to examine the robustness of the GHI to small changes in its aggregation function. Spearman rank correlation coefficients for the equally weighted GHI and additional GHI versions with varied weights are computed to this end (see Table 6). The rank correlations are used to assess whether the index versions are "redundant," that is, whether the rankings based on indices with modified weights essentially contain the same information as the ranking of the equally weighted GHI. Thresholds for redundancy are defined by McGillivray and White (1993) as follows: if the rank correlation coefficient between two indicators is not significantly less than 0.90, this is considered "Level 1" redundancy, and if the rank correlation coefficient is not significantly less than 0.70, this is considered "Level 2" redundancy. The correlation coefficients for the total sample range from 0.969 to 1.000, showing a very high level of redundancy of the index versions with modified weights as compared to the equally weighted GHI (see the rank correlations of the index components with the GHI in Table 15 below for comparison).

Table 6: Rank correlations between the GHI (with equal weights) and index versions with modified weights

	Weights for components of modified GHI			Full sample (n = 119)	Low GHI (n = 39)	Medium GHI (n = 40)	High GHI (n = 40)
	Proportion of undernourished	Children underweight	Under-five mortality rate				
GHI 11	***0.10***	0.45	0.45	0.969***	0.874***	0.831***	0.749***
GHI 12	0.45	***0.10***	0.45	0.977***	0.901***	0.828***	0.858***
GHI 13	0.45	0.45	***0.10***	0.994***	0.987***	0.936***	0.951***
GHI 21	***0.20***	0.40	0.40	0.991***	0.952***	0.947***	0.898***
GHI 22	0.40	***0.20***	0.40	0.993***	0.955***	0.950***	0.940***
GHI 23	0.40	0.40	***0.20***	0.998***	0.996***	0.967***	0.984***
GHI 41	***0.40***	0.30	0.30	0.998***	0.986***	0.978***	0.979***
GHI 42	0.30	***0.40***	0.30	0.998***	0.986***	0.985***	0.982***
GHI 43	0.30	0.30	***0.40***	1.000***	0.998***	0.996***	0.994***
GHI 61	***0.60***	0.20	0.20	0.976***	0.898***	0.777***	0.882***
GHI 62	0.20	***0.60***	0.20	0.975***	0.916***	0.853***	0.731***
GHI 63	0.20	0.20	***0.60***	0.989***	0.959***	0.935***	0.880***

Source: Author's calculations; see Table 1 in Box 1 of Chapter 2 for the data sources.

Note: *** Significant at the 1 percent level.

High redundancy of the index versions is also observed when subsamples of the data for low, medium, and high GHI levels are analyzed. Considering that the cases in the sample range from the least developed to relatively more developed countries (such as Kuwait in terms of economic development, or some Eastern European countries with regard to social indicators), rank correlations for all 119 countries may not be adequate to detect changes in the information content of the indices. For this reason, the total sample is split into tertiles with low, medium, and high GHI (using the equally weighted index version). Unless the weights are changed considerably—raising the weight of one component to 0.60 or reducing it to 0.10 while assigning half the difference to unity to each of the other two components—the index versions with modified weights are still highly redundant to the equally weighted GHI for the subsamples. Even for relatively large changes in weights, the rank correlation coefficients do not fall below the threshold for Level 2 redundancy.

These findings show that the GHI ranking is not very sensitive to moderate changes in weighting factors. Therefore, the preference for a particular set of weights (equal weights as opposed to any other possible set of weights) should not give reason for too much concern. Whereas the weighting of composite indices tends to be a point of contention due to its unavoidable arbitrariness, investing time and resources in improving the database might often be more worthwhile than discussing weights extensively.

Another option to modify the aggregation function of the index is the standardization of its components, which is usually applied to harmonize different measurement units (Szilágyi 2000). Yet, even for indicators that are expressed in a common metric (such as the three GHI components that are all given as percentages), standardization may be advisable. The reason is that the range and standard deviation of the partial indicators matter for the purpose of index calculation. If the standard deviations and the differences between minimum and maximum values are widely divergent across indicators, the component with the largest variance might dominate the variation of the index despite equal weighting. Principal components analysis cannot account for this problem, because the weights obtained from this method are essentially based on the Pearson’s correlation coefficients, which are independent of the scale of the variables. Thus, applying weights selected on the basis of factor analysis is not suitable to avoid this type of "unintentional weighting," if no technique to standardize the partial indicators is used.

The three indicators selected for the GHI share a common metric that limits their theoretical minimum and maximum values to 0 and 100, respectively, but nevertheless, there are noteworthy divergences in their descriptive statistics (see Table 4 on page 66). The mean values and standard deviations of the proportion of undernourished and underweight in children are roughly similar. Yet, for the under-five mortality rate (which is also expressed as a percentage, not per 1,000 live births), mean and standard deviation are only about half of the values of the first two indicators, and the ranges of the three indicators also differ.

The sensitivity of the GHI ranking to the use of different standardization techniques for the index components is tested to evaluate the potential bias introduced into the index by the diverging standard deviations of its components. This is done by calculating three alternative GHI versions and evaluating their rank correlations with the simple natural average of the partial indicators according to the formula in Box 1 in Chapter 2. These alternative indices are based on the following three types of standardization for index components that are exemplified in the literature (Szilágyi 2000; Wiesmann 2004):

1. Forming the ratio of the value of country j (X_j) to an estimated maximum value for variable X:

$$\text{standardized value of } X_j = X_j / X_{max(est)}, \tag{1}$$

   where $X_{max(est)}$ is the estimated maximum value for variable X.

2. Relating the country value X_j to the actual minimum and maximum values for variable X:

$$\text{standardized value of } X_j = (X_j - X_{min}) / (X_{max} - X_{min}), \tag{2}$$

   where X_{min} is the actual minimum value for variable X in the data set, and X_{max} is the actual maximum value for variable X in the data set.

3. Normalization of X_j–values, i.e., transforming the variable so that it has a mean value of 0 and a standard deviation of 1:

$$\text{standardized value of } X_j = (X_j - m_X) \,/\, s_X, \tag{3}$$

where m_X is the mean of variable X, and s_X is the standard deviation of variable X.

For the first type of standardization, upper limits that are safely above the actual maximum values in the data set are chosen: 80 percent for the proportion of undernourished (the Democratic Republic of Congo held the maximum value of 73 percent for this indicator in 2000-02 after an increase by 5 percentage points from 1995-97), 72 percent for underweight in children (71.3 percent was the highest national prevalence since the beginning of systematic data collection, which was found in India in 1974-1979 [see WHO 2006]), and 40 percent for under-five mortality (corresponding to the extremely high child mortality rate of 400 per 1,000 live births in Mali in 1960 [see UNICEF 1995]). For the second type of standardization, the actual minimum and maximum values shown in Table 4 are used. For the third version, the index components are normalized using their mean values and standard deviations. Equal weights of one-third are applied for the aggregation of the standardized index components, as for the GHI based on unstandardized partial indicators.

As Table 7 shows, the rankings based on index versions with standardized components essentially contain the same information as the ranking of the GHI without standardization. For the total sample, the rank correlation coefficients are above 0.99, and fairly above 0.90 for the three subsamples, showing the high redundancy of the index versions with standardized components. Yet, these findings may not be sufficient to justify the use of unstandardized index components: the above comparison looks only at a cross-section of countries, and not at the impact of standardization on changes in the index over time.

Table 7: Rank correlations between the GHI and three GHI versions based on standardized index components

	GHI based on unstandardized components			
	Full sample (n = 119)	Low GHI (n = 39)	Medium GHI (n = 40)	High GHI (n = 40)
GHI based on standardization (1) with estimated maximum values	0.996***	0.981***	0.977***	0.961***
GHI based on standardization (1) with actual minimum and maximum values	0.993***	0.955***	0.952***	0.933***
GHI based on standardization (3) with mean values and standard deviations	0.994***	0.971***	0.961***	0.941***

Source: Author's calculations, see Table 1 in Box 1 of Chapter 2 for the data sources.

Note: *** Significant at the 1 percent level.

Trends for 85 countries for which GHI scores for 1981, 1992, and 2003 are available are examined to see how the standardization of index components affects changes over time. Although the drop in sample size seems large, the majority of developing countries is still covered. The following countries cannot be considered for longitudinal analysis due to lack of data: 21 countries in transition (all countries in Eastern Europe and the Former Soviet Union in the data set except for Albania; many of these states came into existence in their present borders after 1990), 7 small countries for which no data on child mortality are reported for 1980 (Comoros, Djibouti, Fiji, the Gambia, Guyana, Suriname, and Swaziland), 3 countries for which data for GHI 2003 are not available (Costa Rica, Libya, and Paraguay), 2 countries that gained independence in the 1990s (Eritrea and Timor-Leste), and South Africa, which lacks data or estimates of child malnutrition for the reference year 1981.

If the actual minimum and maximum values in the data set or the means and standard deviations are not constant over the years, using these values for each year to standardize the index components destroys intertemporal comparability of index scores. As the descriptive statistics in Table 8 show, there are changes in the minimum and maximum values, means, and standard deviations of the GHI components over the years. The relative change in mean value from 1981 to 2003 was largest for the under-five mortality rate: it was cut by about 37 percent, with the largest reduction in the first half of this period (see Table 9; in order to calculate the relative changes, mean values were not weighted by population size, because exploring the characteristics of the data set was the purpose, not describing global trends). The relative change of the mean value of the proportion of undernourished was much more modest, only -12.6 percent, the decrease being solely attributable to a decline in the period 1992-2003. Due to the addition of 21 countries in transition from 1997 on, the declines in mean values would even be larger if all countries with available data for each year were considered and the sample was not restricted to a balanced panel of 85 countries.

Table 8: Descriptive statistics for GHI 1981, 1992, and 2003, and components

	Mean	Standard Deviation	Minimum	Maximum
GHI reference year 1981				
Proportion of undernourished (in percent)	24.6	16.1	1.0	69.0
Prevalence of underweight in children (in percent)	26.1	14.9	1.1	70.1
Under-five mortality rate (in percent)	14.9	8.1	2.6	33.0
Global Hunger Index	21.9	11.1	2.9	46.4
GHI reference year 1992				
Proportion of undernourished (in percent)	24.9	16.9	1.0	74.7
Prevalence of underweight in children (in percent)	22.9	13.3	1.2	61.8
Under-five mortality rate (in percent)	11.2	7.8	1.1	32.0
Global Hunger Index	19.7	10.8	1.9	47.2
GHI reference year 2003				
Proportion of undernourished (in percent)	21.5	15.8	1.0	71.0
Prevalence of underweight in children (in percent)	20.2	13.1	0.7	48.3
Under-five mortality rate (in percent)	9.4	7.5	0.7	28.4
Global Hunger Index	17.0	10.5	1.8	42.7

Source: Author's calculations; see Table 1 in Box 1 of Chapter 2 for the data sources.

Note: Number of cases: 85 (all countries for which data for all three years are available).

Table 9: Changes in mean values of the GHI and its components

	Relative changes in mean values (in percent)		
Reference period (first year as a base year)	**1981-2003**	**1981-1992**	**1992-2003**
Proportion of undernourished (in percent)	-12.6	1.2	-13.7
Prevalence of underweight in children (in percent)	-22.6	-12.3	-11.8
Under-five mortality rate (in percent)	-36.9	-24.8	-16.1
Global Hunger Index	-22.4	-10.0	-13.7

Source: Author's calculations; see Table 1 in Box 1 of Chapter 2 for the data sources.

Notes: Number of cases: 85. Mean values were not weighted by population size to calculate change rates.

The changes in descriptive statistics over the years preclude the use of the second and third standardization method employing actual minimum and maximum values or means and standard deviations (see formulas (2) and (3) above). Evidently, transforming the mean values of the index components to zero by subtracting the mean for each year would result in an index that failed to indicate the overall gains in the fight against hunger and undernutrition from 1981 to 2003. Applying the mean and standard deviation for 1981 to all reference years alike would not result in an effective normalization for later points in time. Furthermore, looking beyond the balanced panel of 85 countries that is used for the purpose of this analysis, the gradual expansion of the sample by countries for which data are unavailable for earlier years would present additional problems for such an approach.

The first standardization method (the use of estimated maximum values that can be held constant over time), however, does not affect intertemporal comparability and can be applied to the data. Moreover, this type of standardization of the three index components (estimated maximum values are 80 percent for the proportion of undernourished, 72 percent for underweight in children, and 40 percent for the under-five mortality rate) produces descriptive statistics that are in a similar range. The discrepancy between the mean, standard deviation, and maximum value of the under-five mortality rate and the respective values of the other two indicators largely disappears, as Table 9 shows. For 1981, the standard deviations of the three indicators are virtually identical. The fact that the mean value of the under-five mortality rate ranges above the mean value of the proportion of undernourished for the reference year 1981, but below the mean value of the proportion of undernourished for the reference year 2003, is attributable to the larger relative reduction in child mortality (compare Table 9).

Two disadvantages of this type of standardization are also apparent: the setting of arbitrary estimated maximum values is unavoidable, and the standardized components are not conducive for ready interpretation. The maximum values chosen here seem reasonable, but there are no compelling arguments to prefer exactly these values to other possible limits for the three indicators. This is especially true if the future possibility of subnational disaggregation of index scores is considered. In areas that are severely affected by drought or conflict, for example, the maximum values previously proposed for standardization might be exceeded. At the same time, the values of the standardized components are not easy to interpret. Taking the example of Bangladesh, it is easy to understand and communicate that 70 percent of children were underweight at about 1981 (see the maximum value in the second line of Table 8). The meaning of the corresponding standardized prevalence of underweight in children of about 97 (see the second line of Table 10) is much less apparent. In fact, standardization of any type would make the GHI less transparent when tracing back levels and trends of index scores to levels and trends of its partial indicators.

Table 10: Descriptive statistics for GHI 1981, 1992, and 2003, and the index components after standardization, using estimated maximum values

	Mean	Standard Deviation	Minimum	Maximum
GHI reference year 1981				
Proportion of undernourished (in %), standardized	30.8	20.1	1.3	86.3
Prevalence of underweight in children (in %), standardized	36.3	20.7	1.5	97.4
Under-five mortality rate (in %), standardized	37.2	20.2	6.5	82.5
Global Hunger Index, based on standardized components	34.8	17.1	5.5	73.8
GHI reference year 1992				
Proportion of undernourished (in %), standardized	31.1	21.1	1.3	93.4
Prevalence of underweight in children (in %), standardized	31.8	18.5	1.7	85.8
Under-five mortality rate (in %), standardized	28.0	19.5	2.8	80.0
Global Hunger Index, based on standardized components	30.3	16.8	3.4	73.1
GHI reference year 2003				
Proportion of undernourished (in %), standardized	26.8	19.7	1.3	88.8
Prevalence of underweight in children (in %), standardized	28.1	18.2	1.0	67.1
Under-five mortality rate (in %), standardized	23.6	18.6	1.8	71.0
Global Hunger Index, based on standardized components	26.2	16.3	2.7	63.2

Source: Author's calculations, see Table 1 in Box 1 of Chapter 2 for the data sources.

Notes: Number of cases: 85 (all countries for which data for all three years are available). For the sake of easier comparison with unstandardized index components, standardized values were multiplied with 100 after dividing values for each country by the estimated maximum value according to formula (1) above.

Moreover, the rank correlations of absolute and relative trends from 1981 to 2003 and from 1992 to 2003 show a high redundancy of changes in the unstandardized GHI version and changes in the standardized GHI version (see Table 11). High redundancy is also found for subsamples by low, medium, and high GHI in 1981, with rank correlation coefficients between 0.96 and 0.99. Relative changes are considered together with absolute changes: on the one hand, a drop of 10 percentage points may be judged differently depending on the initial level of the indicator (which could be 70 percent or 20 percent, for example); on the other hand, relative changes may attach too much importance to small and possibly statistically insignificant differences when the initial level of the indicator is very low.

Table 11: Rank correlations between changes in the GHI based on unstandardized components and a GHI version based on standardized components

	Absolute Change in *unstandardized* GHI			
	Full sample (n = 85)	**Low GHI in 1981 (n = 28)**	**Medium GHI in 1981 (n = 28)**	**High GHI in 1981 (n = 29)**
Absolute change in GHI based on *standardized* components				
Reference period 1981-2003	0.987***	0.967***	0.982***	0.982***
Reference period 1992-2003	0.982***	0.976***	0.970***	0.984***
	Relative Change in *unstandardized* GHI (in %)			
Relative change in GHI based on *standardized* components (in %)				
Reference period 1981-2003	0.984***	0.990***	0.982***	0.959***
Reference period 1992-2003	0.985***	0.990***	0.977***	0.978***

Source: Author's calculations; see Table 1 in Box 1 of Chapter 2 for the data sources.

Notes: Estimated maximum values were used for standardization, see Formula (1). *** Significant at the 1 percent level.

The observation of high redundancy for changes in the two index versions provides another argument against standardizing the index components prior to aggregation. Yet, the rank correlations between changes in the unstandardized and changes in the standardized GHI might be so high because changes in one component could strongly dominate changes in the overall index, and this may not be appropriately taken care of by the standardization applied. This concern gives reason for further investigation of the statistical properties of the index.

While the standardization procedure almost equalizes the cross-sectional standard deviations of the index components for the three years under consideration (see Table 10), differences in the standard deviations of absolute changes over time are narrowed, but not eliminated. This is evident from Table 12, which shows the descriptive statistics for trends between 1981 and 2003 for the GHI and its components, comparing standardized and unstandardized versions. Without standardization, the standard deviation of absolute changes in the proportion of undernourished is about 3.5 times higher than the corresponding statistic for absolute changes in the under-five mortality rate, and about 1.7 times higher after standardization. The minimum and maximum values indicate that the trends in the proportion of undernourished after 1981 were much more divergent than for the under-five mortality rate, with very large absolute increases as well as very large absolute decreases for the former indicator. For child mortality, dropping rates are the norm, and slight rises for a few countries are the exception.

Table 12: Descriptive statistics for absolute and relative changes in the GHI based on unstandardized components and absolute and relative changes in a GHI version based on standardized components

	Mean	Standard Deviation	Minimum	Maximum
Absolute changes in reference period 1981-2003 in *unstandardized* GHI components				
Proportion of undernourished (in percent)	-3.2	14.7	-48.0	34.0
Prevalence of underweight in children (in percent)	-5.9	9.3	-28.4	15.2
Under-five mortality rate (in percent)	-5.5	4.2	-19.0	2.2
Global Hunger Index (GHI)	-4.8	6.9	-21.0	15.0
Absolute changes in reference period 1981-2003 in *standardized* GHI components				
Proportion of undernourished (in percent)	-4.0	18.4	-60.0	42.5
Prevalence of underweight in children (in percent)	-8.2	12.9	-39.4	21.1
Under-five mortality rate (in percent)	-13.6	10.6	-47.5	5.5
Global Hunger Index (GHI)	-8.6	9.9	-29.2	19.3
Relative changes in reference period 1981-2003 in *unstandardized* GHI components (in percent)				
Proportion of undernourished (in percent)	-0.6	63.2	-78.7	325.0
Prevalence of underweight in children (in percent)	-23.7	33.2	-87.2	58.7
Under-five mortality rate (in percent)	-42.2	27.6	-83.3	27.9
Global Hunger Index (GHI)	-24.2	29.2	-73.0	54.0
Relative changes in reference period 1981-2003 in *standardized* GHI[a] (in percent)				
Global Hunger Index (GHI)	-27.9	26.9	-73.6	43.9

Source: Author's calculations, see Table 1 in Box 1 of Chapter 2 for the data sources.

Notes: Number of cases: 85 (all countries for which data for all three years are available). For the sake of easier comparison with unstandardized index components, standardized values were multiplied with 100 after dividing values for each country by the estimated maximum value according to Formula (1) above.

[a] For this type of standardization, there is no difference between relative changes in standardized and unstandardized GHI components.

How do divergent standard deviations of changes in the index components affect the way trends in the three index components are represented in GHI trends? To examine this question, rank correlations for changes in the GHI and changes in its components are calculated for standardized and unstandardized index versions (Tables 13 and 14). This approach takes into account that trends in one index component may be reflected in GHI trends both directly (via the inclusion of the indicator) and indirectly (via correlations with changes in the other indicators).

Table 13: Rank correlations between changes in the GHI based on unstandardized components and changes in the index components

	Absolute change in *unstandardized* GHI			
	Full sample (n = 85)	**Low GHI in 1981 (n = 28)**	**Medium GHI in 1981 (n = 28)**	**High GHI in 1981 (n = 29)**
Absolute change in GHI components				
Reference period 1981-2003				
Proportion of undernourished (in percent)	0.873***	0.842***	0.839***	0.850***
Prevalence of underweight in children (in percent)	0.573***	0.643***	0.694***	0.507***
Under-five mortality rate (in percent)	0.510***	0.682***	0.311	0.427**
Reference period 1992-2003				
Proportion of undernourished (in percent)	0.772***	0.456**	0.708***	0.859***
Prevalence of underweight in children (in percent)	0.586***	0.627***	0.453**	0.664***
Under-five mortality rate (in percent)	0.527***	0.373*	0.423**	0.505***
	Relative change in *unstandardized* GHI (in percent)			
Relative change in GHI components (in percent)				
Reference period 1981-2003				
Proportion of undernourished (in percent)	0.705***	0.750***	0.853***	0.867***
Prevalence of underweight in children (in percent)	0.613***	0.251	0.706***	0.539***
Under-five mortality rate (in percent)	0.692***	0.540***	0.668***	0.546***
Reference period 1992-2003				
Proportion of undernourished (in percent)	0.647***	0.498***	0.789***	0.829***
Prevalence of underweight in children (in percent)	0.690***	0.645***	0.547***	0.768***
Under-five mortality rate (in percent)	0.629***	0.524***	0.666***	0.584***

Source: Author's calculations; see Table 1 in Box 1 of Chapter 2 for the data sources.

Note: * Significant at the 10 percent level; ** significant at the 5 percent level; *** significant at the 1 percent level.

The rank correlation of absolute changes in the unstandardized GHI with absolute changes in the proportion of undernourished of 0.87 is indeed high for the total sample and the reference period 1981 to 2003. As compared to the rank correlations with the other two components that range from 0.51 to 0.57, this indicates a relatively dominant role of the first indicator. While the correlations for the proportion of undernourished remain high across the subgroups, exceeding Level 1 redundancy (threshold 0.70) and approaching Level 2 redundancy (threshold 0.90), the correlations of the other two components vary.

For the group with low GHI in 1981, absolute changes in the under-five mortality rate are relatively highly correlated with unstandardized GHI trends from 1981 to 2003, and likewise for absolute changes in underweight prevalence for the medium tertile. For absolute changes in the shorter period 1992 to 2003 and also for the relative changes expressed in percent, the representation of the three components in the index is more balanced for the full sample. Because the tertiles are formed by absolute levels of the GHI in 1981 and not by the changes themselves, correlations for the subgroups can be even higher than correlations for the total sample.

The standardization of components prior to aggregation enhances the correlations of changes in the under-five mortality rate with changes in the index. As compared to the rank correlations of absolute trends in the under-five mortality rate with absolute trends in the unstandardized GHI from 1981 to 2003, the correlation coefficients increase by about 0.10 for the total sample and the subgroups (see Tables 13 and 14). At the same time, the rank correlations with absolute changes in the proportion of undernourished drop, but to a lesser degree (still amounting to 0.85 for the total sample). Yet, the pattern of the correlations with absolute changes in the components is not fundamentally different for the two index versions.

For the relative changes, there are similar differences as for the absolute changes when comparing Tables 13 and 14: rank correlation coefficients increase for the under-five mortality rate and decrease for the proportion of undernourished. For underweight prevalence in children, the changes are smaller, and the correlation coefficients either increase or decrease. Again, the overall pattern is similar for the two index versions.

Considering the losses in transparency and communicability and the disadvantage of arbitrary limit setting that are associated with standardization, the GHI based on unstandardized components is preferred. Applying more complex methods of standardization that could possibly equalize the standard deviations of changes in the

Table 14: Rank correlations between changes in the GHI based on standardized components and changes in the index components

	Absolute change in *standardized* GHI			
	Full sample (n = 85)	Low GHI in 1981 (n = 28)	Medium GHI in 1981 (n = 28)	High GHI in 1981 (n = 29)
Absolute change in GHI components				
Reference period 1981-2003				
Proportion of undernourished (in percent)	0.850***	0.759***	0.825***	0.788***
Prevalence of underweight in children (in percent)	0.538***	0.554***	0.643***	0.536***
Under-five mortality rate (in percent)	0.616***	0.806***	0.429**	0.520***
Reference period 1992-2003				
Proportion of undernourished (in percent)	0.736***	0.347*	0.625***	0.841***
Prevalence of underweight in children (in percent)	0.539***	0.620***	0.365*	0.628***
Under-five mortality rate (in percent)	0.655***	0.503***	0.603***	0.598***
	Relative change in *standardized* GHI (in percent)			
Relative change in GHI components (in percent)				
Reference period 1981-2003				
Proportion of undernourished (in percent)	0.632***	0.704***	0.807***	0.780***
Prevalence of underweight in children (in percent)	0.637***	0.226	0.685***	0.588***
Under-five mortality rate (in percent)	0.775***	0.569***	0.764***	0.695***
Reference period 1992-2003				
Proportion of undernourished (in percent)	0.591***	0.463**	0.719***	0.782***
Prevalence of underweight in children (in percent)	0.667***	0.639***	0.521***	0.719***
Under-five mortality rate (in percent)	0.725***	0.567***	0.762***	0.694***

Source: Author's calculations, see Table 1 in Box 1 of Chapter 2 for the data sources.

Note: Since the standardization does not affect the ranking order of changes in the index components, the changes in unstandardized components are used for calculating rank correlations. * Significant at the 10 percent level, ** significant at the 5 percent level, *** significant at the 1 percent level.

three indicators does not seem advisable. The fact that trends in the proportion of undernourished have taken a less favorable course than trends in child mortality, with widely divergent paths for individual countries, can essentially not be blamed on index construction. In addition, the under-five mortality rate is a final outcome with other causal factors than hunger and undernutrition. Therefore, it can be argued that this indicator should not dominate the intertemporal variation of the GHI. The proportion of undernourished and the prevalence of underweight in children, which are more immediate measures of hunger and undernutrition, should have a comparatively larger impact on changes in the index over time.

In summary, the GHI is found to be quite robust in the face of changes in its aggregation function resulting either from different types of standardization applied to its components, or from moderate variations of weighting factors. Thereby, it fulfils the respective requirement postulated by Ryten (2000) for composite indices. For the sake of simplicity, transparency, and communicability, unstandardized components and equal weights are used when calculating the GHI.

Technical Notes on Redundancy

A new index, such as the Global Hunger Index, and new international indicators in general, ought to show non-redundancy vis-à-vis indicators that are already widely used (Ryten 2000). If a new indicator does not include a significant amount of new information, there is no evident reason why it should be compiled or calculated. Redundancy is usually measured by means of the Spearman rank correlation coefficient. The problem with the judgment of redundancy, which has been hotly debated with reference to the Human Development Index, lies in the fact that no commonly accepted threshold exists. Therefore, an arbitrary threshold differentiating redundancy from non-redundancy has to be specified. As already mentioned, McGillivray and White have proposed that if the rank correlation coefficient between two indicators is not significantly less than 0.90, it may be defined as "Level 1" redundancy. If the rank correlation coefficient is not significantly less than 0.70, it is called "Level 2" redundancy (see McGillivray and White 1993, an article referring to the Human Development Index).

Furthermore, analyzing subsets of the total data set by means of rank correlations can provide valuable insights, because indicators that fail to pass the redundancy test for the whole data set may differ substantially in rank correlations within subsets. The information gained by a newly introduced indicator or index is as yet only fully acknowledged if the country data set is divided into groups of equal size, e.g., tertiles or quartiles according to the level of GNI per capita or the measure in question (see McGillivray and White 1993 and Noorbakhsh 1998 for examples).

For the total sample of 119 countries, the GHI shows some redundancy as compared to its components, but the index is much less redundant for subsamples of the data set. Table 15 gives Spearman rank correlation coefficients for the GHI and its partial indicators. The correlation coefficient between the proportion of undernourished and the GHI amounts to 0.90, and the correlation coefficient between the prevalence of underweight in children and the GHI is about 0.89; thus, the threshold for Level 1 redundancy of 0.90 is met or almost met. The correlation coefficient between the under-five mortality rate and the GHI is only slightly lower, at 0.87, and therefore still close to the threshold for Level 1 redundancy. However, the picture looks different for the subsamples, i.e., the tertiles by GHI level: all correlation coefficients indicate that the threshold for Level 1 redundancy is not attained. The threshold for Level 2 redundancy of 0.70 is only exceeded by the correlation between the proportion of undernourished and the GHI for countries with high GHI scores (0.75), and only the correlation between underweight prevalence in children and the GHI for countries with low GHI (0.69) gets close to this threshold. The correlation between the under-five mortality rate and the GHI for countries with high GHI is only 0.35 and merely significant at the 5 percent level.

Table 15: Rank correlations between the GHI and its components

	Full sample (n = 119)	Low GHI (n = 39)	Medium GHI (n = 40)	High GHI (n = 40)
Proportion of undernourished				
Correlation Coefficient	0.898***	0.634***	0.476***	0.745***
P-Value	(0.000)	(0.000)	(0.002)	(0.000)
Children underweight				
Correlation Coefficient	0.888***	0.693***	0.636***	0.380**
P-Value	(0.000)	(0.000)	(0.000)	(0.015)
Under-five mortality rate				
Correlation Coefficient	0.867***	0.538***	0.466***	0.348**
P-Value	(0.000)	(0.000)	(0.002)	(0.028)

Source: Author's calculations, see Table 1 in Box 1 of Chapter 2 for the data sources.

Notes: * significant at the 10 percent level; ** significant at the 5 percent level; *** significant at the 1 percent level. P-values are given in parentheses.

In conclusion, the GHI contributes the most additional information, above that of its components, when subgroups of the total sample are considered. Surely the relatively lower correlation coefficients for the three subgroups partly arise from the lower sample size, because rank correlations tend to decrease with smaller numbers of cases. But the drop in correlation coefficients cannot be solely accounted for by reduced sample size, as a comparison with the rank correlations between differently calculated GHI versions above illustrates, where correlation coefficients remain very high even if the total sample is split up (see Tables 6 and 7). Regarding the size and significance of the coefficients for the total sample and the subsamples, the findings in this section are quite similar to results of studies about the HDI (McGillivray and White 1993).

Moreover, large ranking differences between the GHI and its components exist for individual countries, despite the relatively high rank correlations for the total sample of 119 countries. Regarding the similar case of the Human Development Index, Lüchters and Menkhoff (1994) have argued that ". . . the often voiced criticism of the high correlation between GDP and HDI misses the point of the explanatory claims made on behalf of the HDI. Rather, the UNDP points explicitly to the marked differences for some countries compared with their GDP rankings" (Lüchters and Menkhoff 1994, 10). This statement also applies to the Global Hunger Index (see the large differences between the GHI rank and ranks on its components in the case of India, as well as other examples of countries with considerable ranking differences that are described in Chapter 3).

Appendix B

Table 16: Rank correlation coefficients between indicators of micronutrient deficiencies, the Global Hunger Index and its components, and dietary energy supply per capita

		Spearman rank correlation coefficients with				
		Single indicators				
Deficient minerals/vitamins and indicators (in percent)	**Number of cases**	**Dietary energy supply per capita**	**Under-nourished in population**	**Under-weight children under 5**	**Under-five mortality rate**	**Global Hunger Index (GHI)**
Iodine						
Low urinary iodine in population	62	0.074 (0.568)	-0.023 (0.859)	0.079 (0.541)	0.120 (0.354)	0.069 (0.594)
Goiter in children aged 6-11 years	90	-0.180* (0.090)	0.183* (0.085)	0.169 (0.110)	0.129 (0.225)	0.194* (0.068)
Iron						
Anemia in pregnant women	66	-0.331*** (0.007)	0.379*** (0.002)	0.424*** (0.000)	0.339*** (0.005)	0.446*** (0.000)
Vitamin A						
Subclinical deficiency[a] in children	58	-0.272** (0.039)	0.318** (0.015)	0.477*** (0.000)	0.506*** (0.000)	0.489*** (0.000)
Clinical deficiency[b] in children	45	-0.403*** (0.006)	0.358** (0.016)	0.337** (0.024)	0.497*** (0.001)	0.488*** (0.001)

Source: Author's calculation based on the following data:

low urinary iodine: latest data from 1993-2003 (UNS SCN 2004), correlations with DES 2000-2002 (FAO 2006b), GHI 2003 (and GHI 1997 for Costa Rica and Paraguay), and underlying data (see Table 1 in Box 1 of Chapter 2 for data sources); goiter rate: latest data from 1985-97 (UNICEF 1999), correlations with DES 1995-97 (FAO 2006b), GHI 1997 and underlying data (see Table 1 in Box 1 of Chapter 2 for data sources); anemia in pregnant women: latest data from 1985-95 (World Bank 1997), correlations with DES 1995-97 (FAO 2006b), GHI 1997, and underlying data (see Table 1 in Box 1 of Chapter 2 for data sources); subclinical vitamin A deficiency: latest data from 1985-2001 (West, Rice, and Sugimoto 2002), correlations with DES 2000-2002 (FAO 2006b), GHI 2003 (and GHI 1997 for Costa Rica), and underlying data (see Table 1 in Box 1 of Chapter 2 for data sources); clinical vitamin A deficiency: latest data from 1983-2001 (West, Rice, and Sugimoto 2002), correlations with DES 2000-2002 (FAO 2006b), GHI 2003, and underlying data (see Table 1 in Box 1 of Chapter 2 for data sources).

Notes: * significant at the 10 percent level; ** significant at the 5 percent level; *** significant at the 1 percent level. p-values are given in parentheses.

[a] Low serum retinol level.

[b] Eye signs.

Table 17: Rank correlation coefficients between international poverty indicators, the Global Hunger Index (GHI) and its components, GNI per capita, dietary energy supply per capita, and the Human Development Index (HDI)

	Spearman rank correlation coefficients with						
	Single indicators						
Poverty indicators (in percent)	Gross national income per capita	Dietary energy supply per capita	Under-nourished in population	Under-weight children under 5	Under-five mortality rate	Human Development Index (HDI)	Global Hunger Index (GHI)
Poverty headcount ratio at $1 a day	-0.671*** (0.000)	-0.692*** (0.000)	0.695*** (0.000)	0.613*** (0.000)	0.700*** (0.000)	-0.713*** (0.000)	0.744*** (0.000)
Poverty gap at $1 a day	-0.724*** (0.000)	-0.697*** (0.000)	0.705*** (0.000)	0.678*** (0.000)	0.757*** (0.000)	-0.767*** (0.000)	0.787*** (0.000)
Poverty headcount ratio at $2 a day	-0.768*** (0.000)	-0.700*** (0.000)	0.715*** (0.000)	0.730*** (0.000)	0.783*** (0.000)	-0.795*** (0.000)	0.823*** (0.000)
Poverty gap at $2 a day	-0.813*** (0.000)	-0.695*** (0.000)	0.717*** (0.000)	0.769*** (0.000)	0.793*** (0.000)	-0.817*** (0.000)	0.846*** (0.000)

Source: Author's calculation based on the following data:

Poverty headcount ratio at $1 a day, poverty gap at $1 a day, poverty headcount ratio at $2 a day, poverty gap at $2 a day (World Bank 2005), latest data from 1998-2003 matched with GHI 2003 and underlying data (65 countries in total), and latest data on poverty from 1992-1997 matched with GHI 1997 and underlying data (24 countries in total) if more recent data on poverty are not available, and for Costa Rica and Paraguay, for which GHI 2003 is not available; see Table 1 in Box 1 of Chapter 2 for data sources of the GHI.

Latest data on poverty from 1998-2003 matched with GNI per capita (World Bank 2005), average 2001-2003, and latest data on poverty from 1992-1997 matched with GNI per capita, average 1995-97, if more recent data on poverty or GHI 2003 not available (89 countries included).

Latest data on poverty from 1998-2003 matched with dietary energy supply per capita (FAO 2006b), average 2000-2002, and latest data on poverty from 1992-1997 matched with dietary energy supply per capita, average 1995-97, if more recent data on poverty or GHI 2003 not available (89 countries included).

Latest data on poverty from 1998-2003 matched with HDI 2003 (UNDP 2005), and latest data on poverty from 1992-1997 matched with HDI 1997 (UNDP 1999), if more recent data on poverty or GHI 2003 not available (87 countries included, 65 with HDI 2003 and 22 with HDI 1997).

Notes: * Significant at the 10 percent level; ** significant at the 5 percent level; *** significant at the 1 percent level. p-values are given in parentheses.

Table 18: Global Hunger Index and underlying data for 1981, 1992, 1997, and 2003

	Proportion of undernourished in total population (in percent)				Prevalence of underweight in children under five (in percent)				Under-five mortality rate (per 1,000 live births)				Global Hunger Index			
	1979-1981	1990-1992	1995-1997	2000-2003	1977-1982	1987-1992	1993-1998	1999-2003	1980	1992	1997	2003	1981	1992	1997	2003
Afghanistan	..	..	..	..	20.9**	40.3**	49.3	..	280	257	257	257	..	..	..	..
Albania	9.2*	12.9*	7.2*	6.0	14.2***	11.3***	11.7***	13.6	57	34	40	21	9.71	9.18	7.62	7.23
Algeria	9.0	5.0	6.0	5.0	18.0**	9.2	12.8	10.4	145	72	39	41	13.83	7.13	7.57	6.50
Angola	29.0	58.0	49.0	40.0	26.3**	35.3**	36.3 x	30.5	261	292	292	260	27.13	40.83	38.17	32.17
Argentina	1.0	2.0	1.0	2.0	3.5**	1.2**	5.4	1.4***	41	24	24	20	2.87	1.87	2.93	1.81
Armenia	..	..	30.3*	34.0	..	..	3.3	2.6	..	34	30	33	..	..	12.19	13.30
Australia	..	..	..	..	..	..	..	..	13	9	6	6	..	..	..	..
Austria	..	..	..	..	..	..	..	..	17	9	5	5	..	..	..	..
Azerbaijan	..	..	30.9*	15.0	..	..	9.3 x	6.7 x	..	53	45	91	..	..	14.89	10.27
Bahrain	..	..	..	..	12.6***	7.4***	8.7	4.4***	..	16	22	15	..	..	..	..
Bangladesh	42.0	35.0	40.0	30.0	70.1	61.8 x	56.3	47.9	211	127	109	69	44.40	36.50	35.73	28.27
Belarus	..	..	1.1*	2.0	..	..	8.2***	1.1***	..	23	18	17	..	..	3.71	1.59
Belgium	..	..	..	..	..	..	..	..	15	11	7	5	..	..	..	..
Benin	36.0	20.0	17.0	15.0	33.4**	23.5**	29.2	22.9	176	147	167	154	29.00	19.40	20.97	17.77
Bhutan	..	..	..	..	..	37.9	..	17.4 x	249	201	121	85	..	..	..	..
Bolivia	26.0	28.0	25.0	21.0	13.2 x	12.0	7.6	7.1***	170	118	96	66	18.73	17.27	14.07	11.57
Bosnia & Herzegovina	..	..	8.8*	8.0	..	..	6.3***	4.1	..	..	16	17	..	..	5.56	4.60
Botswana	28.0	23.0	27.0	32.0	34.4**	26.8**	17.2	12.5	94	58	49	112	23.93	18.53	16.37	18.57
Brazil	15.0	12.0	10.0	9.0	7.0**	7.0	5.7	3.8***	93	65	44	35	10.43	8.50	6.70	5.43
Bulgaria	..	..	8.7*	11.0	6.9***	4.1***	..	..	25	20	19	15	..	..	..	..
Burkina Faso	64.0	21.0	19.0	19.0	32.2**	27.1**	32.7	37.7	246	150	169	207	40.27	21.03	22.87	25.80
Burundi	38.0	48.0	63.0	68.0	25.9**	31.0	38.5***	41.1 x	193	179	176	190	27.73	32.30	39.71	42.70
Cambodia	62.0	43.0	44.0	33.0	44.3**	37.7**	47.4	45.2	330	184	167	140	46.43	33.03	36.03	30.73
Cameroon	20.0	33.0	33.0	25.0	17.3	15.1	20.6 x	17.0***	173	117	99	166	18.20	19.93	21.17	19.52
Canada	..	..	..	..	..	..	..	..	13	8	7	6	..	..	..	..
Central African Republic	22.0	50.0	51.0	43.0	52.7**	31.9**	23.2	24.3	202	179	173	180	31.63	33.27	30.50	28.43
Chad	69.0	58.0	49.0	34.0	32.1**	30.6**	38.8	28.0	254	209	198	200	42.17	36.50	35.87	27.33
Chile	7.0	8.0	5.0	4.0	1.1	2.0**	0.8	0.7	35	18	13	9	3.87	3.93	2.37	1.87
China	30.0	16.0	12.0	11.0	23.8**	17.4	9.0	10.0	65	43	47	37	20.10	12.57	8.57	8.23
Colombia	22.0	17.0	13.0	13.0	16.7	10.1	8.4	6.7	59	20	30	21	14.87	9.70	8.13	7.27
Comoros	56.6*	47.6*	53.5*	59.7*	23.0***	19.1 x	25.8	25.4	..	130	93	73	..	26.58	29.55	30.81
Congo, Democratic Rep.	37.0	32.0	60.0	71.0	27.9**	33.2**	34.4	31.0	204	188	207	205	28.43	28.00	38.37	40.83
Congo, Rep.	29.0	54.0	59.0	37.0	39.1**	23.9	..	..	125	110	108	108	26.87	29.63	..	..
Costa Rica	8.0	6.0	5.0	4.0	6.0	2.3	4.1 x	..	29	16	14	10	5.63	3.30	3.50	..
Côte d'Ivoire	7.0	18.0	16.0	14.0	14.1**	12.3**	21.3 x	21.2	180	124	150	192	13.03	14.23	17.43	18.13
Croatia	..	..	10.0*	7.0	..	..	0.6	0.5***	..	..	9	7	..	..	3.84	2.72
Cuba	3.0	8.0	18.0	3.0	8.3**	8.4**	4.1***	3.9	26	11	8	8	4.63	5.83	7.62	2.57
Cyprus	..	..	..	..	..	..	..	..	..	11	9	5	..	..	..	..
Czech Republic	..	..	..	..	..	1.0	..	..	..	12	7	4	..	..	..	..
Denmark	..	..	..	..	..	..	..	..	10	8	6	4	..	..	..	..
Djibouti	55.4*	57.6*	39.6*	29.2*	..	22.9	18.2	19.7***	..	158	156	138	..	32.09	24.45	20.90
Dominican Republic	25.0	27.0	26.0	25.0	14.0**	10.3	5.9	5.3	94	50	53	35	16.13	14.10	12.40	11.27
Ecuador	12.0	8.0	5.0	4.0	19.0**	16.5	14.3	12.0***	101	59	39	27	13.70	10.13	7.73	6.22

(continued)

	Proportion of undernourished in total population (in percent)				Prevalence of underweight in children under five (in percent)				Under-five mortality rate (per 1,000 live births)				Global Hunger Index			
	1979-1981	1990-1992	1995-1997	2000-2003	1977-1982	1987-1992	1993-1998	1999-2003	1980	1992	1997	2003	1981	1992	1997	2003
Egypt, Arab Republic of	8.0	4.0	3.0	3.0	14.9 x	10.4	10.7	8.6	180	55	73	39	13.63	6.63	7.00	5.17
El Salvador	17.0	12.0	14.0	11.0	20.9**	15.2	11.8	9.9 x	120	63	36	36	16.63	11.17	9.80	8.17
Eritrea	..	..	68.0	73.0	..	..	43.7	39.6	..	..	116	85	..	..	41.10	40.37
Estonia	..	..	3.7*	5.0	..	..	3.0***	4.8***	..	24	14	9	..	..	2.70	3.56
Ethiopia[a]	53.5*	74.7*	61.0	46.0	38.1	43.8 x	46.6***	47.2	260	208	175	169	39.20	46.44	41.72	36.70
Fiji	..	10.1*	7.6*	5.1*	10.3***	8.4***	7.9	2.1***	..	29	24	20	..	7.14	5.97	3.07
Finland	..	..	..	..	..	..	..	..	9	7	4	5	..	..	..	..
France	..	..	..	..	..	..	..	..	13	9	5	5	..	..	..	..
Gabon	13.0	10.0	8.0	6.0	16.1**	15.1**	10.0***	11.9	194	158	145	91	16.17	13.63	10.83	9.00
Gambia, The	57.0	22.0	31.0	27.0	25.6**	17.1**	26.2	17.2	..	220	87	123	..	20.37	21.97	18.83
Georgia	..	..	21.2*	27.0	..	..	3.4***	3.1	..	29	29	45	..	..	9.17	11.53
Germany	..	..	..	..	..	..	..	..	16	8	5	5	..	..	..	..
Ghana	61.0	37.0	18.0	13.0	30.9**	27.1	27.3	22.1	157	170	107	95	35.87	27.03	18.67	14.87
Greece	..	..	..	..	..	..	..	..	23	9	8	5	..	..	..	..
Guatemala	17.0	16.0	21.0	24.0	43.6	28.5	26.6	21.9 x	136	76	55	47	24.73	17.37	17.70	16.87
Guinea	30.0	39.0	31.0	26.0	23.4	24.0**	22.8***	23.2	276	230	201	160	27.00	28.67	24.64	21.73
Guinea-Bissau	39.6*	23.0*	30.7*	34.4*	23.7***	21.4***	23.5***	25.0	290	239	220	204	30.75	22.74	25.39	26.61
Guyana	13.0	21.0	12.0	9.0	22.1**	18.0**	18.3	13.6	..	65	82	69	..	15.17	12.83	9.83
Haiti	47.0	65.0	59.0	47.0	37.4	26.8	27.5	17.2	195	133	132	118	34.63	35.03	33.23	25.33
Honduras	31.0	23.0	21.0	22.0	21.2**	20.6	25.4	16.0 x	100	58	45	41	20.73	16.47	16.97	14.03
Hungary	..	..	..	..	..	2.2	..	..	26	16	11	8	..	..	..	..
India	38.0	25.0	21.0	21.0	68.0**	61.0	45.4	47.5 x	177	124	108	87	41.23	32.80	25.73	25.73
Indonesia	26.0	9.0	6.0	6.0	45.7**	35.5	34.0	27.3	128	111	68	41	28.17	18.53	15.60	12.47
Iran, Islamic Republic of	9.0	4.0	3.0	4.0	14.4***	17.2***	10.9	9.5***	126	58	35	39	12.00	9.00	5.80	5.80
Iraq	..	..	..	..	14.5**	11.9	13.6***	15.9	83	80	122	125	..	..	..	..
Ireland	..	..	..	..	..	..	..	..	14	6	7	6	..	..	..	..
Israel	..	..	..	..	..	..	..	..	19	11	6	6	..	..	..	..
Italy	..	..	..	..	..	..	..	..	17	10	6	4	..	..	..	..
Jamaica	8.0	14.0	11.0	10.0	9.3	4.6	4.2	3.8	39	14	11	20	7.07	6.67	5.43	5.27
Japan	..	..	..	..	3.7	..	..	..	11	6	6	4	..	..	..	..
Jordan	6.0	4.0	7.0	7.0	9.4***	6.4	5.1	4.4	66	30	24	28	7.34	4.47	4.83	4.73
Kazakhstan	..	..	2.2**	13.0	..	..	8.3	4.2	..	50	44	73	..	..	4.96	8.17
Kenya	25.0	44.0	38.0	33.0	22.0	18.0	22.1	19.9	112	74	87	123	19.40	23.13	22.93	21.73
Korea, Democratic Rep.[b]	19.0	18.0	35.0	36.0	34.7***	25.2***	24.7***	19.5	43	33	30	55	19.35	15.51	20.91	20.33
Korea, Republic of[c]	1.0	2.0	2.0	1.0	..	..	..	..	18	9	6	5	..	..	..	..
Kuwait	4.0	23.0	5.0	5.0	10.1**	5.0**	1.7	4.8***	35	17	13	9	5.87	9.90	2.67	3.56
Kyrgyz Republic	..	..	15.2*	6.0	..	..	11.0	12.3***	..	60	48	68	..	..	10.34	8.36
Lao PDR	32.0	29.0	28.0	22.0	37.6**	34.0**	40.0	40.4	190	145	122	91	29.53	25.83	26.73	23.83
Latvia	..	..	4.8*	4.0	..	..	3.6***	3.0***	..	26	20	12	..	..	3.46	2.74
Lebanon	8.0	2.0	3.0	3.0	14.0**	8.9**	3.0	3.8***	40	44	37	31	8.67	5.10	3.23	3.28
Lesotho	26.0	17.0	14.0	12.0	13.3	15.8	16.0	18.0	173	156	137	84	18.87	16.13	14.57	12.80
Liberia	22.0	34.0	42.0	46.0	20.8**	20.1**	26.5***	26.5	235	217	235	235	22.10	25.27	30.66	32.00
Libya	0.0	0.0	0.0	0.0	4.1**	4.0**	4.7	..	150	104	25	16	6.37	4.80	2.40	..
Lithuania	..	..	3.1*	0.0	..	..	2.8***	6.8***	..	20	15	11	..	..	2.47	2.64

(continued)

	Proportion of undernourished in total population (in percent)				Prevalence of underweight in children under five (in percent)				Under-five mortality rate (per 1,000 live births)				Global Hunger Index			
	1979-1981	1990-1992	1995-1997	2000-2003	1977-1982	1987-1992	1993-1998	1999-2003	1980	1992	1997	2003	1981	1992	1997	2003
Macedonia, FYR	..	..	12.0*	11.0	..	..	5.2***	5.7 x	..	..	23	11	..	..	6.50	5.93
Madagascar	18.0	35.0	40.0	37.0	30.1**	40.9	40.0	40.2***	216	168	158	126	23.23	30.90	31.93	29.92
Malawi	26.0	50.0	40.0	33.0	21.2 x	27.6	29.9	25.4	290	226	215	178	25.40	33.40	30.47	25.40
Malaysia	4.0	3.0	2.0	2.0	29.8**	25.6	20.1	19.0	42	19	11	7	12.67	10.17	7.73	7.23
Mali	59.0	29.0	32.0	29.0	34.3**	25.1	40.0	33.2	310	220	239	220	41.43	25.37	31.97	28.07
Mauritania	35.0	15.0	11.0	10.0	31.0	47.6	23.0	31.8	249	206	183	183	30.30	27.73	17.43	20.03
Mauritius	10.0	6.0	6.0	6.0	28.0**	17.0**	14.9	3.6***	42	24	23	18	14.07	8.47	7.73	3.80
Mexico	5.0	5.0	5.0	5.0	16.7**	14.2	9.5***	7.5	81	33	35	28	9.93	7.50	5.99	5.10
Moldova	..	..	10.1*	11.0	..	..	7.6***	4.8***	..	36	31	32	..	..	6.93	6.32
Mongolia	27.0	34.0	46.0	28.0	17.3***	12.3	13.0***	12.7	112	80	150	68	18.50	18.10	24.68	15.83
Morocco	10.0	6.0	6.0	7.0	16.6**	9.5	9.0	8.4***	145	61	72	39	13.70	7.20	7.40	6.42
Mozambique	54.0	66.0	58.0	47.0	43.8**	46.8**	26.1	23.7	269	287	208	158	41.57	47.17	34.97	28.83
Myanmar	19.0	10.0	7.0	6.0	42.0	36.7	28.2	31.8	146	113	114	107	25.20	19.33	15.53	16.17
Namibia	25.0	35.0	36.0	22.0	18.2***	26.2	23.5***	24.0	114	79	75	65	18.19	23.03	22.32	17.50
Nepal	46.0	20.0	26.0	17.0	66.2**	50.5**	46.9	48.3	177	128	104	82	43.30	27.77	27.77	24.50
Netherlands	..	..	..	..	0.7	..	..	..	11	7	6	5	..	..	..	..
New Zealand	..	..	..	..	..	..	..	..	16	10	7	6	..	..	..	..
Nicaragua	26.0	30.0	33.0	27.0	10.5	11.7***	12.2	9.6	143	76	57	38	16.93	16.44	16.97	13.47
Niger	32.0	41.0	42.0	34.0	49.0**	42.6	49.6	40.1	320	320	320	262	37.67	38.53	41.20	33.43
Nigeria	40.0	13.0	9.0	9.0	30.4**	35.3	35.0 x	28.7	196	191	187	198	30.00	22.47	20.90	19.17
Norway	..	..	..	..	..	..	..	..	11	8	4	4	..	..	..	..
Oman	..	..	..	..	24.9***	24.3	17.8	14.0***	95	31	18	12	..	..	..	..
Pakistan	31.0	24.0	19.0	20.0	54.7	40.2	38.2	35.0	151	137	136	103	33.60	25.97	23.60	21.77
Panama	22.0	21.0	23.0	26.0	15.7	11.0**	8.1	8.2***	31	20	20	24	13.60	11.33	11.03	12.21
Papua New Guinea	..	..	..	..	29.9	28.5***	26.5***	27.4***	95	77	112	93	..	..	..	..
Paraguay	13.0	18.0	13.0	14.0	7.0**	3.7	2.2***	..	61	34	33	29	8.70	8.37	6.16	..
Peru	28.0	42.0	19.0	13.0	16.7**	10.7	7.8	7.1	130	65	56	34	19.23	19.73	10.80	7.83
Philippines	27.0	26.0	23.0	22.0	33.2	33.4	31.8	27.1***	70	60	41	36	22.40	21.80	19.63	17.55
Poland	..	..	..	..	..	..	..	..	24	16	11	7	..	..	..	..
Portugal	..	..	..	..	..	..	..	..	31	13	8	5	..	..	..	..
Qatar	..	..	..	..	..	..	5.5	3.7***	..	33	20	15	..	..	..	..
Romania	..	3.2*	0.9*	1.0	5.9***	5.7	3.6***	3.2	36	28	26	20	..	3.89	2.36	2.07
Russian Federation	..	..	5.9*	4.0	..	..	3.0	2.7***	..	32	25	21	..	..	3.80	2.93
Rwanda	24.0	44.0	52.0	37.0	35.5*8	29.4	27.3	24.3	222	222	170	203	27.23	31.87	32.10	27.20
Saudi Arabia	3.0	4.0	4.0	3.0	14.9**	12.6**	15.4	10.7***	90	40	28	26	8.97	6.87	7.40	5.44
Senegal	19.0	23.0	25.0	24.0	19.4**	21.6	22.3	22.7	221	145	124	137	20.17	19.70	19.90	20.13
Serbia & Montenegro	..	..	3.2*	11.0	..	..	1.6	1.9	..	22	21	14	..	..	2.29	4.77
Sierra Leone	40.0	46.0	44.0	50.0	23.2	28.7	25.5***	27.2	301	249	316	284	31.10	33.20	33.70	35.20
Singapore	..	..	..	..	14.4	..	..	3.4	13	7	4	3	..	..	..	..
Slovak Republic	..	..	4.4*	5.0	..	..	6.1***	3.9***	..	14	11	8	..	..	3.87	3.22
Slovenia	..	..	..	..	..	..	..	..	..	..	6	4	..	..	..	..
Somalia	..	..	..	..	41.9**	38.8**	..	25.8	246	211	211	225	..	..	..	..
South Africa	5.5*	5.8*	7.3*	5.5*	..	9.6***	8.2 x	10.9 x	91	70	65	66	..	7.46	7.32	7.66
Spain	..	..	..	..	..	..	..	..	16	9	5	4	..	..	..	..

(continued)

	Proportion of undernourished in total population (in percent)				Prevalence of underweight in children under five (in percent)				Under-five mortality rate (per 1,000 live births)				Global Hunger Index			
	1979-1981	1990-1992	1995-1997	2000-2003	1977-1982	1987-1992	1993-1998	1999-2003	1980	1992	1997	2003	1981	1992	1997	2003
Sri Lanka	22.0	28.0	26.0	22.0	47.5	37.3	37.7	26.4 x	52	19	19	15	24.90	22.40	21.87	16.63
Sudan	24.0	32.0	23.0	27.0	26.4**	33.7**	33.9	40.7	200	166	115	93	23.47	27.43	22.80	25.67
Suriname	17.0	13.0	10.0	11.0	..	..	15.2***	13.2	..	35	30	39	..	..	9.39	9.37
Swaziland	14.0	14.0	23.0	19.0	12.6**	8.8**	9.6***	10.3	..	107	94	153	..	11.17	14.00	14.87
Sweden	..	..	..	..	..	..	..	..	9	7	4	3	..	..	..	..
Switzerland	..	..	..	..	..	..	..	..	11	9	5	5	..	..	..	..
Syrian Arab Republic	3.0	5.0	4.0	4.0	16.0**	12.5**	12.9	6.9	73	40	33	18	8.77	7.17	6.73	4.23
Tajikistan	..	..	29.8*	61.0	..	..	22.2***	18.0***	..	85	76	118	..	..	19.86	30.25
Tanzania	23.0	37.0	50.0	44.0	23.8**	28.9	30.6	29.4	202	176	143	165	22.33	27.83	31.63	29.97
Thailand	28.0	28.0	20.0	20.0	36.0	22.2	17.6	14.5***	61	33	38	26	23.37	17.83	13.80	12.36
Timor-Leste[d]	..	..	..	8.7*	..	..	..	45.8	..	..	..	124	..	..	..	22.29
Togo	31.0	33.0	25.0	26.0	23.2**	24.4 x	26.2 x	23.3***	175	137	125	140	23.90	23.70	21.23	21.10
Trinidad and Tobago	5.0	13.0	15.0	12.0	10.0**	6.7	6.5***	5.9	40	22	17	20	6.33	7.30	7.73	6.63
Tunisia	2.0	1.0	1.0	1.0	14.8**	10.3	9.0	4.0	102	38	33	24	9.00	5.03	4.43	2.47
Turkey	2.0	2.0	2.0	3.0	13.2**	10.5**	8.3	9.5***	141	87	45	39	9.77	7.07	4.93	5.45
Turkmenistan	..	..	14.6*	9.0	..	..	11.8***	12.0	..	91	78	102	..	..	11.40	10.40
Uganda	31.0	24.0	26.0	19.0	24.8**	23.0	25.5	22.9	181	185	137	140	24.63	21.83	21.73	18.63
Ukraine	..	..	6.3*	3.0	..	..	2.4***	0.9 x	..	25	24	20	..	..	3.71	1.97
United Arab Emirates	1.0	4.0	2.0	2.0	..	..	..	..	64	22	10	8	..	..	..	..
United Kingdom[e]	..	..	..	..	2.1	..	..	..	14	9	7	6	..	..	..	..
United States of America	..	..	..	..	..	1.4	..	1.6	15	10	8	8	..	..	..	..
Uruguay	3.0	6.0	4.0	4.0	6.5**	7.4	4.4	2.8***	42	22	21	14	4.57	5.20	3.50	2.74
Uzbekistan	..	..	10.4*	26.0	..	..	18.8	7.9	..	68	60	69	..	..	11.74	13.60
Venezuela, RB	4.0	11.0	16.0	17.0	10.2	5.1	5.3	4.4	42	24	25	21	6.13	6.17	7.93	7.83
Vietnam	33.0	31.0	23.0	19.0	53.1**	41.9	39.8	33.8	105	49	43	23	32.20	25.93	22.37	18.37
Yemen, Republic of	40.0	34.0	36.0	36.0	55.7	30.0	46.1	40.3***	210	177	100	113	38.90	27.23	30.70	29.19
Zambia	30.0	48.0	48.0	49.0	19.3**	25.2	23.5	28.1	160	202	202	182	21.77	31.13	30.57	31.77
Zimbabwe	30.0	45.0	47.0	44.0	23.5**	12.0	15.5	13.0	125	86	80	126	22.00	21.87	23.50	23.20

Source: See Table 1 in Box 1 of Chapter 2 for the data sources.

Notes: x = The prevalence of underweight in children refers to an age group other than under-five year olds (for example, 0-2.99 years, 0.5-4.99 years, see WHO 2006 for details) and was adjusted by the author to reflect the prevalence rate in under-fives (see Wiesmann 2004 for the method of calculating and applying correction factors). * Author's estimates of the proportion of undernourished, based on models with dietary energy supply per capita and the logarithm of dietary energy supply per capita as independent variables; ** estimates of underweight prevalence in children as reported in UN ACC/SCN 1993; *** author's estimates of underweight prevalence in children, based on OLS and fixed effects models with subsets of the following variables as independent variables: Gross National Income per capita, logarithm of Gross National Income per capita, dietary energy supply per capita or logarithm of dietary energy supply per capita, percent of dietary energy from animal sources, dietary energy from animal sources squared, literacy rate, ratio of male to female literacy rate, total population, proportion of the population aged 0-14 years, urban population in percent, regional dummy variables, and interactions with regional dummy variables (the independent variables are not meant to be determinants of food insecurity, but were chosen for the purpose of prediction, to yield regression equations with the highest possible R-squared to fill in missing values; details can be obtained from the author upon request). For Iran and Jordan, the author's estimates for underweight prevalence in children were used for the GHI reference years 1981 and 1992, although estimates from UN ACC/SCN 1993 are also available. The reason is that survey data for these two countries released after the publication of UN ACC/SCN 1993 suggest that the estimates in this report were overstated.

(continued)

Table 18 (continued)

(notes)

As compared to an earlier publication of the Global Hunger Index (Wiesmann et al. 2006), the data in this table include the following revisions: a correction of the proportion of undernourished for Colombia in 1979-81; a correction of the under-five mortality rate for Estonia in 1997 and for the under-five mortality rates for the Democratic Republic of Congo and the Republic of Congo; and the replacement of the under-five mortality rate for 1993 by the under-five mortality rate for the actual year of 1992. In addition, a more elaborate approach was followed to calculate the proportion of undernourished for countries with less than 2.5 percent undernourished, for which FAO did not publish estimates in 2004 and 2005: in these cases, the number of people undernourished and the total population (in millions) from FAO (2004) was used to calculate the proportion of undernourished. Where the calculated proportion of undernourished turned out greater than 2.5 percent due to the rounding of the population numbers to one decimal for some smaller countries, the figure for the proportion of undernourished was cut to 2 percent. This last step was not applied in Wiesmann et al. (2006) and leads to changes in the data for Lebanon in 1990-92, the United Arab Emirates in 1995-97 and 2000-02, and for Malaysia in 2000-02.

[a] For years earlier than 1993, when the secession of Eritrea took place, numbers for Ethiopia include the area of Eritrea.

[b] North Korea.

[c] South Korea.

[d] East Timor.

[e] Great Britain and Northern Ireland.

Appendix C

Table 19: Regional coverage of Global Hunger Index scores

Region	Remarks	Proportion of the population for which GHI scores are available			
		1981	1992	1997	2003
		(percent)			
Eastern Europe and the former Soviet Union[a]	All countries	0.7	6.3	83.0	83.0
	Not including the following countries in this region that are not considered for GHI calculation: the Czech Republic, Hungary, Poland, and Slovenia	0.8	7.4	97.5	97.7
Latin America and the Caribbean	All countries	98.4	98.8	98.9	97.1
Middle East and North Africa	All countries	90.6	90.0	89.4	87.2
	Not including the following countries in this region that are not considered for GHI calculation: Israel and the United Arab Emirates	92.6	92.1	91.5	89.6
South Asia	All countries	98.3	98.2	98.4	97.7
Southeast Asia[b]	All countries	87.7	89.0	89.1	89.5
	Not including the following countries in this region that are not considered for GHI calculation: Australia, Japan, New Zealand, the Republic of Korea,[c] and Singapore	98.8	99.4	99.0	99.3
Sub-Saharan Africa	All countries	90.0	98.0	98.2	98.1

Source: Population data are taken from World Bank 2006b; for some countries, they were requested from the United Nations Population Division (UN Population Division 2006).

Notes: The proportion of the population covered by GHI scores shown in this table is based on the total population of each region, if not stated otherwise. Countries with less than 500.000 inhabitants are considered, although no GHI scores were calculated for these small countries. For the regional aggregation of GHI scores, the proportion of undernourished was weighted with the total population (World Bank 2005), and the prevalence of underweight in children under five and the under-five mortality rate were weighted with the population of children under five years (using data from UN Population Division 2006) prior to the aggregation of the three index components.

[a] No regional aggregates were calculated for 1981 and 1992 for Eastern Europe and the former Soviet Union. For this region, GHI 1981 is only available for Albania, and GHI 1992 only for Albania and Romania.

[b] The region referred to as Southeast Asia includes East Asia and the Pacific.

[c] South Korea.

Appendix D

Table 20: Regressions of Global Hunger Index and components on GNI per capita and war dummy variable

Dependent variable	Global Hunger Index	
R-squared, adjusted	0.755	
Number of observations	110	
Independent variables	**coefficient**	**t-statistics**
log GNI per capita[a]	-9.93	(16.69)***
war dummy[b]	3.89	(3.29)***
constant	93.04	(19.20)***

Dependent variable	Proportion of undernourished (in percent)	
R-squared, adjusted	0.573	
Number of observations	110	
Independent variables	**coefficient**	**t-statistics**
log GNI per capita[a]	-13.02	(10.74)***
war dummy[b]	6.91	(2.87)***
constant	121.72	(12.32)***

Dependent variable	Prevalence of underweight in children (in percent)	
R-squared, adjusted	0.540	
Number of observations	110	
Independent variables	**coefficient**	**t-statistics**
log GNI per capita[a]	-10.40	(10.29)***
war dummy[b]	4.40	(2.19)**
constant	98.65	(11.98)***

Dependent variable	Under-five mortality rate (in percent)	
R-squared, adjusted	0.648	
Number of observations	110	
Independent variables	**coefficient**	**t-statistics**
log GNI per capita[a]	-6.36	(13.69)***
war dummy[b]	0.36	(0.39)
constant	58.75	(15.51)***

Source: Author's calculations, see Table 1 in Box 1 of Chapter 2 and notes below for the data sources.

Notes: GHI 2003 and its components were used as dependent variables (and GHI 1997 and its components for Costa Rica and Paraguay, for which GHI 2003 is not available). The cross-country regressions are not suitable to establish a causal link between war and hunger, but they show systematic differences for war countries. Controlling for heteroskedasticity changes the level of significance of the coefficients in one case: significance drops from 5 percent to 10 percent for the war dummy variable in the regression of underweight prevalence in children (p-value = 0.063 instead of 0.031). * Significant at the 10 percent level, ** significant at the 5 percent level, *** significant at the 1 percent level.

[a] The logarithm of Gross National Income per capita (2001-2003 average for countries with GHI 2003, and 1995-97 average for two countries with GHI 1997), based on purchasing power parity and expressed in constant 2000 international dollars (data source: World Bank 2005).

[b] The war dummy variable is 0 for non-war countries and 1 for countries that were involved in war between 1989 and 2003 (information on wars is taken from UCDP 2006).

Table 21: Regressions of Global Hunger Index and components on GNI per capita and dummy variable for HIV prevalence > 10 percent

Dependent variable	**Global Hunger Index**	
R-squared, adjusted	0.734	
Number of observations	99	
Independent variables	**coefficient**	**t-statistics**
log GNI per capita[a]	-10.48	(16.30)***
HIV dummy[b]	3.92	(2.04)**
Constant	98.27	(19.22)***
Dependent variable	**Proportion of undernourished (in percent)**	
R-squared, adjusted	0.533	
Number of observations	99	
Independent variables	**coefficient**	**t-statistics**
log GNI per capita[a]	-13.89	(10.45)***
HIV dummy[b]	7.08	(1.78)*
Constant	130.15	(12.31)***
Dependent variable	**Prevalence of underweight in children (in percent)**	
R-squared, adjusted	0.496	
Number of observations	99	
Independent variables	**coefficient**	**t-statistics**
log GNI per capita[a]	-10.96	(9.90)***
HIV dummy[b]	0.70	(0.21)
Constant	104.24	(11.84)***
Dependent variable	**Under-five mortality rate (in percent)**	
R-squared, adjusted	0.678	
Number of observations	99	
Independent variables	**coefficient**	**t-statistics**
log GNI per capita[a]	-6.59	(14.03)***
HIV dummy[b]	3.99	(2.85)***
Constant	60.40	(16.17)***

Source: Author's calculations; see Table 1 in Box 1 of Chapter 2 and notes below for the data sources.

Notes: GHI 2003 and its components were used as dependent variables (and GHI 1997 and its components for Costa Rica and Paraguay, for which GHI 2003 is not available). The cross-country regressions are not suitable to establish a causal link between HIV prevalence and hunger, but they show systematic differences for countries with high prevalence rates. Countries with higher income inequality tend to have higher prevalence rates (compare data on the Gini coefficient from World Bank 2005 and on HIV prevalence from UNAIDS/WHO 2006), and both poverty and wealth entail particular risk factors for HIV transmission (Gillespie and Greener 2006). The multicollinearity between income inequality and HIV prevalence confounds the relationship between the HIV dummy variable and the GHI. Controlling for heteroskedasticity changes the level of significance of the coefficients in one case: significance drops from 5 percent to 10 percent for the HIV dummy variable in the regression of the GHI (p-value = 0.059 instead of 0.044). * Significant at the 10 percent level, ** significant at the 5 percent level, *** significant at the 1 percent level.

[a] The logarithm of Gross National Income per capita (2001-2003 average for countries with GHI 2003, and 1995-97 average for two countries with GHI 1997), based on purchasing power parity and expressed in constant 2000 international dollars (data source: World Bank 2005).

[b] The HIV dummy variable is 0 for countries with an HIV prevalence rate lower than or equal to 10 percent, and 1 for countries with an HIV prevalence rate greater than 10 percent (data source: UNAIDS/WHO 2006).

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