SAFEGUARDING FOOD SECURITY IN VOLATILE GLOBAL MARKETS

EDITED BY

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Chapter 27

Investing towards a world free of hunger: lowering vulnerability and enhancing resilience

Josef Schmidhuber and Jelle Bruinsma[1]

Why invest in agriculture?

The need for increased investment in agriculture is a recurring argument throughout this volume. The underlying premise is that investment has the power to reduce poverty and hunger, the twin causes of vulnerability. Around 75 percent of the world's poor live in rural areas. Many directly depend on agriculture or draw a large share of their incomes from agriculture-related activities. Others work as small entrepreneurs in the agriculture-related processing, machinery, storage, seed, feedstuffs or fertilizer sectors. While so many poor and hungry depend on agriculture for their livelihoods, a profound and prolonged lack of investment in agriculture has held back the overall productivity of the sector, sometimes so much that it has lost its function as a viable base for poverty reduction. Importantly, lack of investment has also reduced the ability of farmers to cope with price volatility and exogenous shocks, both weather-related and economic ones.

But there is also ample evidence that this lack of investment can be addressed successfully and that investments can have a massive effect in reducing poverty. Econometric analysis presented in the World Development Report 2008 (World Bank, 2008), for instance, suggests that Gross Domestic Product (GDP) growth arising from agriculture is almost four times as effective in reducing poverty as GDP originating outside the sector. As a labour-intensive sector, agriculture can absorb underused labour, such as landless rural workers and farmers who own too little to make a living. Moreover, agricultural growth reduces food prices and acts as a multiplier in local economies, eventually leading to higher rural wages and vibrant rural markets where farmers and workers spend their earnings.

This chapter updates and expands the FAO Anti-Hunger Programme of 2003 (FAO, 2003). It assesses the investment needs, identifies the instruments and sketches out financing possibilities in agriculture to reach a world free of hunger by 2025. Why 2025? By setting an annual target, we cast a feasible trajectory for the necessary action. The rationale that has motivated this assessment is manifold. First, actual trends to halve hunger by 2015 are drifting away from the stated goals at a worrisome pace. In 2007 and 2008, high and volatile

[1] Josef Schmidhuber, Statistics Division (FAO) and Jelle Bruinsma, Economic and Statistics Department (FAO). The authors express their sincere thanks to FAO colleagues for direct assistance and time for discussions. A particular thanks goes to Elcio Guimaraes for the preparation of Table 27.10.

food prices lifted hunger by 75 million people and the 2009 a global economic crisis pushed the overall total above the mark of 1 billion (FAO, 2009). The chances to reach the 2015 goals have become slim. Second, it cannot suffice - and it is even morally questionable - to aim for merely halving hunger; the ultimate goal must be a world that is completely free from the scourge of chronic undernourishment.

Despite these setbacks, there are encouraging signs that the fight against hunger is receiving new attention. In 2001, Brazil launched a zero hunger programme and in 2006, 27 Latin American countries joined and committed themselves to reaching the same goal by 2025 (FAO, 2006). Developed countries alike have recognized the importance and urgency to resume the fight against hunger. They committed USD 20 billion to improved food security at the G-8 summit in L'Aquila in July 2009 and have put agriculture at centre stage in living up to their commitments. Sketching out how a world free of hunger can be reached by 2025, how agriculture can help accomplish this goal and what sources of finance can be tapped is at the heart of this assessment.

The 2003 Anti-Hunger Programme (AHP) covered the "incremental annual public investment needed to meet the WFS goal"[2] in five broad investment areas, namely: improvements of agricultural productivity, development and conservation of natural resources, expansion of rural infrastructure and market access, strengthening of the capacity for knowledge generation and dissemination and ensuring access to food for the most needy.

The analysis that follows quantifies the additional investment needs (in terms of incremental public investment in agriculture and related supporting areas including complementary policy measures) required to eliminate hunger by 2025. The proposed actions fall into two broad categories. The first comprises a set of investment proposals for agriculture and rural areas designed to create new income opportunities for the rural poor and thus afford more people access to food in a sustainable manner. These measures include investments in rural infrastructure and institutions, research, development and extension as well as natural resource conservation. The second set of measures focuses on direct assistance and includes productive safety nets for poor farmers as well as food safety nets for rural and urban people without access to productive assets. The natural corollary of an integrated programme of investment and built-in safety nets is improving the resilience of those most at risk to economic shocks and climatic disturbances, especially those that cause irreversible damage to human capital and social systems.

The proposal in a nutshell

The overall envelope we propose amounts to an annual total of USD 50.2 billion (Table 27.1). This overall amount would be allocated to five broad categories: rural infrastructure and markets (USD 18.5 billion), natural resource conservation (USD 9.4 billion), research and development (R&D) and extension (USD 6.3 billion) and building rural institutions (USD 5.6 billion). Investments in agriculture and rural areas would be supplemented by expenditures in two safety net programmes: food safety nets with an annual volume of USD 7.5 (food and cash for the most needy) and productive safety nets (provision of basic inputs for small farmers to resume or intensify farming) with annual expenditures of USD 2.9 billion.

[2] The 1996 World Food Summit (WFS) target aims at halving the number of undernourished people by 2015 (from its base level in 1990/92).

Table 27.1: Incremental annual public investment needed to eradicate hunger by 2005

Priority area for investment	Estimated annual cost* *(USD billions)*
1. Expand rural infrastructure and market access	18.5
2. Develop and conserve natural resources	9.4
3. Research, development and extension	6.3
4. Rural institutions	5.6
5. Expenditures for safety nets	
Productive farm safety nets	2.9
Food safety nets	7.5
Total investments and safety net expenditures	50.2

*All costs in 2009 prices.
Source: Authors.

Investments by region

A breakdown of the overall total by region provides a highly differentiated picture. One obvious result is that the largest shares of the proposed programme would be allocated to sub-Saharan Africa and South Asia. Together the two regions account for more than USD 30.9 billion, which is 62 percent of overall programme and 71 percent of the safety net measures.

For sub-Saharan Africa, the high investment requirements reflect the considerable catch-up needed between the baseline outcome and a zero hunger scenario. These baseline projections (see Schmidhuber et al., 2009) suggest that sub-Saharan Africa would account for only a small share of total future investment flows (10 percent of the total), reflecting the region's generally labour-intensive, capital-saving forms of production. It is important to recall that (i) these projections include a large amount of private flows and (ii) they assume that no extra effort will be made towards reducing hunger faster or eliminate it completely. The stubbornly high prevalence of hunger has been a consequence of slow growth in investment in sub-Saharan Africa. Because of the high prevalence of undernourishment (now and in 2025 under the base line projection), it is not surprising that sub-Saharan Africa is expected to require a high amount of public investments to make more and faster progress towards a zero hunger environment.

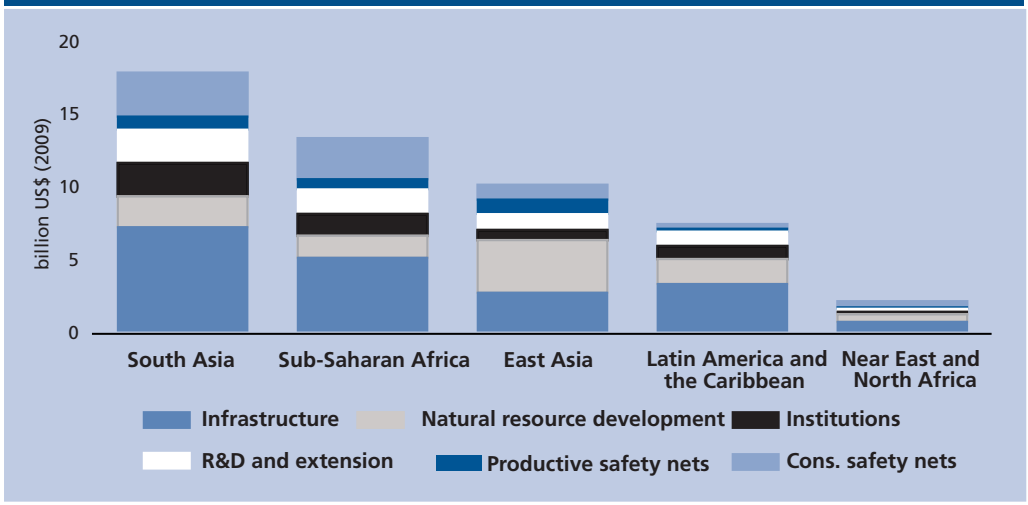
Only South Asia with its large agriculture base and still larger population would need more public investments to reach a zero hunger outcome by 2025. South Asia and sub-Saharan Africa together would absorb more than 60 percent of the incremental public investment needs; investment in rural infrastructure would alone absorb nearly 40 percent of the needs in both regions (Figure 27.1). Both regions would also require high investments in their woefully inadequate storage facilities.

Investing in people

While technically less straightforward than the breakdowns by sector or region, fund allocation by type of asset is equally interesting. To keep matters simple, suffice it to distinguish between investments in people and investments in physical assets.

A fundamental challenge for any investment in poverty reduction is the fact that the poor, the very target of such programmes, hold too few or no physical assets in which to

Figure 27.1: Allocation of funds by region



Source: Authors.

invest. After all, that's why they are poor. Pro-poor growth programmes must therefore not rely exclusively on investments in physical assets, they should also include people and in particular women, promoting their skills, their empowerment and thus their ability to share in the benefits from investments in physical assets. Investing in human capital was an important element of this proposed programme from the outset. The programme allocates over USD 17 billion - or one-third of the overall envelope - to investments in people, including investments in and expenditures for food safety nets, extensions and institutions. In addition, poor people stand to benefit indirectly from jobs created in rural areas (e.g. from the construction and maintenance of infrastructure, storage or processing facilities) even if they own no physical assets.

Investing in productivity and sustainability

In addition, the proposed programme can be broken down by investments in output quantity versus quality of, or differently put, in productivity-enhancing measures and sustainability-promoting ones.

For hunger and poverty reduction to be sustainable, investments must focus on sustainable production methods. The proposed programme addresses this through various efforts. Investments in infrastructure (rural roads, storage) will help reduce losses, improve quality and lift prices received by farmers. They thus help producers generate more income with fewer inputs. A rough estimate suggests that about USD 12.4 billion of the overall investment envelope will either directly or indirectly help reduce losses or improve input use efficiency. Second, the programme directly promotes the adoption of more sustainable production methods. Proposed measures include payments to shift to no-till/conservation agriculture, integrated pest management, or integrated plant nutrition systems. About USD 3.6 billion are earmarked for the adoption of more sustainable production methods. And finally, the programme invests in skills and know-how, which make farmers more efficient in using their inputs and more knowledgeable about the long-term costs they face

by pursuing unsustainable production methods. While the effects of improved skills affect many aspects and may have only indirect effects, it is worth noting that about USD 4.1 billion have been allocated to this end.

The benefits

The basic idea of this investment proposal is to create sustainable income-generating activities, numerous and significant enough to generate the purchasing power required for the poor to escape hunger, thereby instilling resilience to weather and economic-induced shocks. These income-generating effects arise in five principal areas. The first stems from higher output of food and fibre and thus higher overall farm revenues. Measured in terms of Gross Value Production (GVP) of agriculture, the expected increase in output would amount to nearly 5 percent by 2025. The increase is derived from the required growth in agricultural output to produce the food and fibre for a global zero hunger outcome by 2025. It is a relatively small amount compared to the overall income effect, and underlines that hunger is above all a poverty problem rather than one of producing enough food. Second, greater benefits can result from all investments that lower input costs and ensure their timely availability, help reduce losses or allow farmers to fetch higher farmgate prices. A third source of income arises from the employment opportunities created in the upstream and downstream sectors, in building and maintaining rural roads, electricity grids or storage facilities. Fourth, a better nutritional status would help break the vicious cycle of mutually reinforcing hunger and poverty.

Hunger perpetuates itself when undernourished mothers give birth to smaller babies who start life with a handicap. Breaking this cycle would unleash enormous productivity potential. Estimates undertaken in the context of the 2003 Anti Hunger Programme (AHP) suggest that every dollar invested in hunger and poverty alleviation would render more than five dollars of benefits as a result of longer and healthier lives for all those who gain from such improvements. The underlying cost benefit calculations in this programme suggest that the benefits are as big as six to one for every dollar invested. Finally, there are difficult-to-quantify but nonetheless important public goods and benefits to be gained. These come from a more efficient use of inputs (e.g. fertilizer or pesticides through Integrated Plant Nutrition Development Systems, IPNS, or Integrated Pest Management, IPM, shallower carbon footprints of agricultural production (e.g. through the adoption of no-till/conservation agriculture), reduced pressure on forests, swampland and other valuable habitats (e.g. through higher land productivity), as well as the broader societal benefits associated with a shift to more sustainable production methods, better flood control, soil conservation, fewer land conflicts or improved biodiversity.

The approach

Setting and defining the goal: what is zero-hunger and how can it be reached?

For practical purposes the assumption is made that a country has reached a state of "zero hunger" when less than 3 percent of its population are chronically undernourished. A further reduction of undernourishment below this level is difficult to achieve and is often a matter of focusing more on empowering people or providing improved health care systems rather than promoting agricultural development. Even in developed countries, pockets of poverty and undernourishment exist amid affluence and advanced social security systems.

Table 27.2: Investment measures by investment area and region (million US Dollars)

	Developing countries	sub-Saharan Africa	Near East and North Africa	Latin America and the Caribbean	South Asia	East Asia
Infrastructure	**18 540**	**5 024**	**629**	**3 248**	**7 062**	**2 577**
Rural roads	8 194	2 409	244	1 808	2 710	1 022
Markets storage processing (incl. PHL)	5 681	1 282	239	487	2 724	948
Food safety and quality	568	128	24	49	272	95
Rural electrification	4 097	1 205	122	904	1 355	511
Natural resource development	**9 434**	**1 522**	**479**	**1 716**	**2 126**	**3 590**
Land resources	1 396	324	14	83	300	674
Water and irrigation	2 178	263	262	57	1 334	262
Plant genetic resources	600	57	49	92	111	292
Animal genetic resources	460	26	37	112	84	201
Fisheries	2 400	118	56	352	207	1 667
Forestry	2 400	734	61	1 020	90	495
Institutions	**5 568**	**1 492**	**177**	**869**	**2 304**	**726**
Rural finance	3 580	1 032	122	574	1 350	502
Mechanization (cooperatives)	1 192	171	34	147	723	117
Land titling tenure security	796	289	21	148	231	108
Research development and extension	**6 311**	**1 739**	**230**	**1 030**	**2 256**	**1 055**
Research and development	2 180	435	77	343	902	422
Extension	4 132	1 304	154	687	1 354	633
Productive safety nets	**2 875**	**672**	**100**	**187**	**888**	**1 029**
Consumptive safety nets	**7 472**	**2 823**	**374**	**257**	**3 001**	**1 018**
Total	50 199	13 272	1 989	7 307	17 636	9 996

The goal of all measures presented in this programme therefore is to reduce hunger below a prevalence level of 3 percent by 2025. The 2025 reference points for all individual countries are taken from the latest update of the baseline projections[3] for undernourishment. Under these baseline projections, 9.1 percent of the developing countries' population (or 591 million people) would on average still be undernourished by 2025 with a wide variation across countries. Some countries are expected to accomplish zero hunger by 2025 even without further assistance, while others would still be saddled with undernourishment levels of well over 20 percent. A meaningful allocation of investment flows therefore requires a detailed country-specific analysis.

The starting point for this analysis is estimating the extent to which the average dietary energy supply (DES, in kcal per person per day) needs to be raised by 2025. Underlying the needed increase in food availability is the incremental income generated by the investment programme. As rising incomes typically lift consumption at low levels more than at already elevated ones (Engel's law), the average increase in the DES level is associated with a decline in the inequality of the calorie distribution (and thus a declining coefficient of variation, CV). The process of lifting average DES levels is therefore combined with a stepwise lowering of the CVs such that the combined effect of higher DES levels and lower CVs gradually reduced undernourishment to levels under 3 percent by 2025.

The results for undernourishment are summarized in Table 27.3. If all countries achieve the stated objective of "zero hunger", the average level of undernourishment in the developing world would fall to 2.9 percent of the population (or 186 million people) by 2025.

3 See Alexandratos (2009).

Table 27.3: Base year and 2025 undernourishment

	Population	Under-nourishment*		Population	Undernourishment			
	2003/05			2025	baseline		zero hunger	
	million	*%*	*million*	*million*	*%*	*million*	*%*	*million*
Developing countries	5 020	16.3	821	6 507	9.1	591	2.9	186
sub-Saharan Africa	696	30.4	212	1 130	15.8	179	3.0	34
Near East/North Africa	413	7.9	33	581	5.2	30	2.2	13
Latin America/Caribbean	544	8.3	45	662	5.0	33	2.7	18
South Asia	1 468	21.4	314	1 933	11.5	223	3.0	58
East Asia	1 898	11.4	217	2 202	5.7	127	2.9	64

* for the 93 developing countries covered in this analysis
Source: FAO (2008).

Not surprisingly, the required adjustments both in terms of DES increases and reductions in inequality are the strongest in sub-Saharan Africa and South Asia, the regions most affected by undernourishment today and expected to be under the baseline projections in 2025.

By how much do incomes have to rise?

The basic idea of this investment proposal is to create sustainable income-generating activities numerous and significant enough to generate the purchasing power required for the poor to escape hunger. This poses the question as to how much incomes would have to rise (relative to those assumed in the baseline projections) to provide the necessary increase in purchasing power. Obviously, this increase depends on a number of factors, including the levels of already-attained consumption, the overall level of economic development and the responsiveness of consumers to step up consumption when incomes rise. These factors[4] were combined to calculate the necessary income and investment increases for 93 individual developing countries. Table 27.4 summarizes the results for regional aggregates.

For the developing countries as a whole, the necessary acceleration in growth appears to be rather modest. On average, annual GDP growth would need to increase from 5.4 percent in the baseline compared with 5.7 percent in the zero hunger scenario; this is equivalent to an income level that by 2025 would be 8 percent above the incomes underlying the baseline projections. While the overall growth requirements appear small, growth needs for individual regions (Table 27.4) are much more pronounced. Small increments in growth would suffice for the Near East and North Africa region, East Asia and Latin America, but the growth would need to be much higher in sub-Saharan Africa (±0.7%) and South Asia (±0.9%). Even larger are the growth needs of individual countries in these regions, many which would need to accelerate GDP growth well in excess of 1 percent per annum.

[4] Increases in food demand were assumed to depend on per capita income with income elasticities ranging from 0.38 in Latin America and East Asia to 0.58 in sub-Saharan Africa; these elasticities are derived from ICP-based estimates provided by USDA and are available at: http://www.ers.usda.gov/data/internationalfooddemand/

Table 27.4: GDP and investment increases needed to reach zero hunger

	GDP growth (% p.a.)		Share agriculture in GDP (%)			Annual investments in ARD		Annual increment
	2005-25		*2005*	*2025*	*2025*	*billion USD 2009*		*million USD 2009*
	BL*	ZH		BL	ZH	BL	ZH	ZH-BL
Developing countries	5.40	5.72	12.7	6.6	6.4	370	413	42 727
sub-Saharan Africa	4.50	5.22	28.8	19.6	17.8	35	45	10 449
Near East/North Africa	4.09	4.15	12.1	8.2	8.2	49	51	1 615
Latin America/Caribbean	4.44	4.61	7.7	4.5	4.4	46	53	7 050
South Asia	5.41	6.29	18.8	10.0	8.8	82	97	14 636
East Asia	6.38	6.59	11.6	4.9	4.8	158	167	8 978

* BL = baseline. ZH = zero hunger. ARD = Agriculture and Rural Development
Source: Authors.

By how much do investments have to rise?

To achieve such an acceleration in GDP growth, investments would need to be raised on an economy-wide basis. The magnitude of the additional investment needs depends, *inter alia*, on the overall level of development of a particular country and the overall share of investments in GDP.[5] Average annual investments in the developing countries as a share of GDP would need to rise from 19 to 20 percent, again with higher growth in the share for sub-Saharan Africa (from 13.8 to 16.0 percent) and South Asia (from 16.2 to 18.9 percent).

In order to gauge the possible contribution to growth that can be drawn from agriculture, the next step was to determine the share of investments in agriculture relative to total investment, whereby agriculture is defined in the broad sense and includes its upstream and downstream industries. Essential here is to form an idea about how important agriculture is in the total economy and how the share of agricultural GDP (AGDP) in total GDP will evolve over time.[6] Table 27.4 shows that for the developing countries as a whole this share was 12.7 percent in the base year and would decline to 6.6 percent by 2025. Naturally, there is a wide variation in the value of these shares, in general they are high in sub-Saharan Africa and low in Latin America (see Table 27.4).

The required investments in agriculture and its downstream industries were derived by applying (for each year from 2005 to 2025) the share of AGDP in GDP to total economy-wide investments. To reach the stated goal of zero hunger, annual investments in developing countries would need to rise from USD 370 billion to USD 413 billion, an increase of USD 42.7 billion (or almost 12 percent), again with wide variations across regions and even wider

5 This was expressed as an "incremental capital-output ratio" (ICOR) with ICOR values set at three for countries with a per capita income up to USD 2 000, at four for GDP per capita up to USD 4 000 and at five for GDP per capita ≥USD 4 000. For each year from 2005 to 2025, the total investments were calculated as $INVT_T = GDP_T \times ICOR_T \times growthGDP$.

6 Base year shares were taken from the 2008 World Development Indicators and the following function was estimated cross-country over 93 countries: $\ln\left(\frac{AG\_GDP}{GDP}\right) = 6.89 - 0.61 \cdot \ln\left(\frac{GDP}{POP}\right)$. Subsequently this function was calibrated to each country's base year values and then used to estimate the 2025 shares.

variations across countries (Table 27.4). For instance, zero hunger in 2025 would require investments in sub-Saharan Africa to be raised by almost 30 percent.

The overall estimate of USD 42.7 billion requires careful interpretation. First, the incremental annual investment estimate presented here (i.e. USD 42.7 billion) refers to investments needed to raise average per capita income in order to provide the purchasing power needed to buy enough food to reach zero hunger. It does not include "investments" in safety nets to improve the access to food for the poor outside their actual incomes. Expenditures for safety nets are estimated to absorb an additional USD 7.5 billion. Second, the investment estimates refer to agriculture in a broad sense, including its upstream and downstream industries as well as supporting activities in agricultural research and development, extension, rural infrastructure and institutions. Investments in each of these activities will be discussed in more detail below. And finally, the applied approach assumes that investments in the other sectors will increase in parallel to those in agriculture. In other words, acceleration in overall economic development is required to alleviate poverty and to reach zero hunger. The extent to which agriculture can contribute to overall economic growth highly depends on factors such as the strength of forward and backward linkages between agriculture and other sectors, the share of income produced in agriculture and its importance for the overall labour market.

Timing, pacing and sequencing of investment flows

The proposed investment plan presents capital needs in equal instalments over time. Importantly, the plan also advocates that the actual allocations be provided in equal annual amounts. This is not an oversight; nor is it simply a choice of convenience to ease the presentation of the proposal and the underlying data on aid and investment flows. It is rather based on the observation that past crises have resulted in patterns of pro-cyclical public investment flows that have most likely exacerbated or induced price swings. The data presented in Box 27.1 suggest that pro-cyclical timing can be observed both for individual areas of public investment (irrigation, R&D, infrastructure, etc.) as well as for foreign public assistance to agriculture in general.

Investment needs beyond 2025

The current proposal has been designed such that the additional income generated in agriculture and rural areas will suffice to create enough purchasing power so that the vast majority of the rural poor can escape the scourge of hunger by 2025. It is, however, not assumed that the measures taken in the years leading up to 2025 will reach fully self-sustained growth strong enough for the public hand to withdraw completely when the proposed programme reaches its stated objective for the first time. Maintaining the achievements will require continuous commitments beyond the 2025 time horizon.

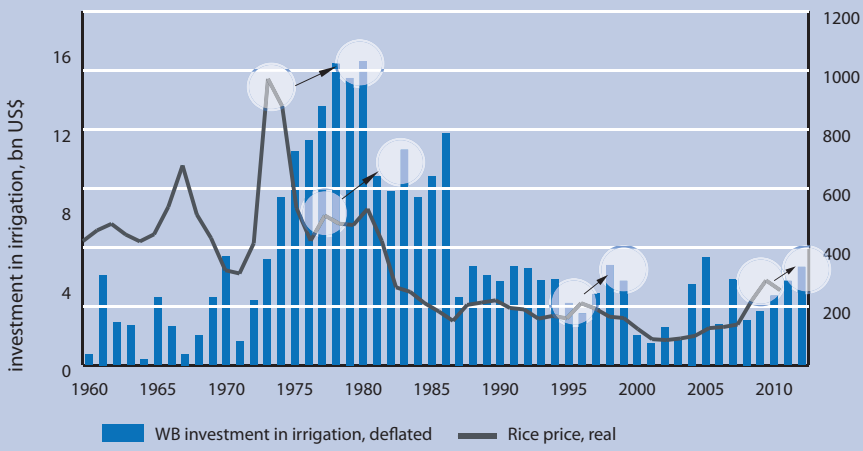
Moreover, a continuously high commitment to provide funding to agriculture and rural areas, extending beyond 2025, will emerge from the need to adapt agriculture to the agro-ecological conditions under climate change. Many countries with a high burden of undernourishment and a high share of agriculture in GDP will be particularly adversely affected and thus require extended assistance to rise to the challenge of climate change.

Box 27.1: Pro-cyclical public investment patterns

The high price event of 2006-08 was not the first of its kind, neither was it the most severe. In real terms, price levels and price volatility were significantly higher in 1973-74 and even more pronounced in the years immediately following World War I (1918-21). Nor was the 1973-74 crisis the most recent episode of price spikes; the last 40 years have seen a number of high price periods (clearly seen in Figure 27.2). Furthermore, the problem of higher price episodes is not limited to rice; in 1996, for instance, annual average maize prices were - in real terms, i.e. adjusted for inflation - above the annual average in 2008, the last record year in terms of nominal prices.

Irrigation and international rice prices

Figure 27.2 World Bank Investment in irrigation (real) and world rice prices (real)

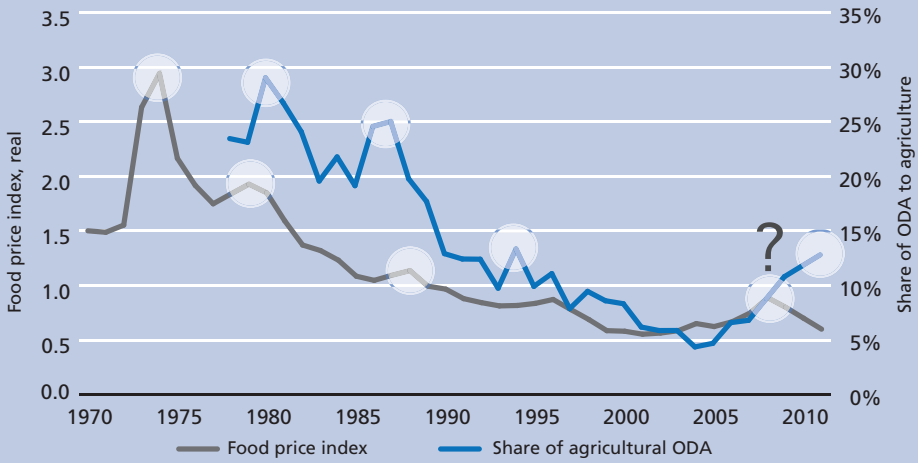


A further inspection of Figure 27.2 reveals more than merely a pronounced cyclicality in international rice prices. It also suggests pro-cyclical public investment flows in response to these price swings. Specifically, it appears that public investments in agriculture follow the general trend but also the swings - with a time lag of three to five years. This means that the public hand invests a lot (little) in production-boosting capital stocks when prices are high (low). By so doing, public investment always arrives at a time when private investors (farmers) have already reacted to price signals and have stepped-up (reduced) commitments to (from) agriculture. This means that the public hand arrives with investments when prices are already low (and thus exacerbate a price trough) and is absent when more output is needed and prices have risen (possibly exacerbating a price peak). Rather than smoothing price swings, public investment thus appears pro-cyclical and increases price swings and volatility. Consequently, public flows: (i) augment the overall risk associated with agricultural production and, rather than crowding in private investors, they crowd them out; and (ii) by augmenting price volatility they lower production relative to a scenario where public investments of the same size are provided in equal instalments.

The problem of pro-cyclical public investment flows should not suggest that the public hand should withdraw from agriculture or related public R&D activities. On the contrary, there is a strong case in favour of public investments in agriculture. Nor does it mean that the public hand should make a particular effort to invest in a counter-cyclical manner. As swings and trends of agricultural prices are impossible to predict, the best approach for the timing and pacing of public investments would be to focus on a long-term development goal (e.g. MDG-1 or the Zero Hunger Goal 2025 put forward here) and then show a firm commitment/steady hand towards reaching that goal regardless of price swings on international food markets.

Agricultural Official Development Assistance (ODA) and food prices in general An inspection of more aggregate data suggests that the problems of pro-cyclical public investment hinders not only individual product areas, but also ODA to agriculture in a more general manner. The basic links are depicted in Figure 27.3. It appears that the share of ODA to agriculture - colloquially put, the barometer of attention in development to food security - follows food prices in a similar way and with similar time lags as illustrated in the case of rice prices and investment in irrigation.

Figure 27.3 Food price index vs share of agricultural ODA



These links can be practically illustrated by summarizing and illuminating the public investment activities that followed the 2008 food price crisis. In reaction to the crisis and to growing public pressure to alleviate food security problems, the international community launched a whole host of activities destined to boost investment in agriculture and increase food production. Without rehashing the details of these programmes, it should suffice here to list the key activities. Examples include the G8 L'Aquila Initiative, the Global Agriculture and Food Security Program (GAFSP) administered by the World Bank, and the World Bank's medium-term plan to double its own commitments to agriculture in a span of the four years following the 2008 crisis. Also worth noting are new commitments to agricultural R&D. The budget for Consultative Group on International Agricultural Research (CGIAR) and its 15 International Research Centers, for instance, is planned to double to nearly USD 1 billion per annum over the next years. In tandem, the internal allocation of funds (Megaprogrammes) will shift back from the original allocation (CGIAR, 2009) towards a production-focused allocation with separate Megaprogrammes for wheat, maize and rice (CGIAR, 2010).

The cyclicality of these efforts is also explained by the fact that the time lags between announced commitments and actual flows can be considerable. Taking the examples above, none of these programmes have rendered flows anywhere near original commitments with the possible exception of the USD 0.9 billion allocated in the GAFSP initiative. The time for decision-making, planning and investment execution of public investors is simply too long, and the international apparatus too slow to invest swiftly enough, i.e. when needs are greatest. These time lags then open the prospect that when and if these programmes come to full fruition, private investors will have already committed to producing more food, the global food security situation may have improved, and public investment will have spurred production in a phase of low prices and structural surpluses. The impossibility to time and pace public investments counter-cyclically has led to the suggestion to allocate the proposed programme in equal installments. This advice may need to be heeded in the allocation of public investment in agriculture more generally.

The programme: investing in safety nets and agricultural productivity

The basic idea of this programme is to create income-generating activities in agriculture and rural areas. The overall envelope required was pegged at an annual total of USD 50.2 billion (see Tables 27.1 and 27.2 for a regional and sectoral breakdown). The overall total would be allocated to five broad categories: rural infrastructure and markets (USD 18.5 billion), natural resource conservation (USD 9.4 billion), research, development and extension (USD 6.3 billion) as well as building rural institutions (USD 5.6 billion). Investments in agriculture and rural areas would be supplemented by expenditures in two safety net programmes: Food safety nets with an annual volume of USD 7.5 (food and cash for the most needy) and productive safety nets (provision of basic inputs for small farmers to resume or intensify farming) with annual expenditures of USD 2.9 billion. Investments in agriculture and rural areas on the one hand and safety nets on the other are the two principal pillars of this programme and correspond to the two tracks of the Anti-Hunger Programme presented in 2003.

Pillar 1: Strengthening safety nets

Food safety nets

A necessary condition for a sustainable, long-term elimination of hunger is the eradication of poverty. But a mere focus on poverty reduction is not always sufficient to address hunger quickly, nor is it always the best strategy to achieve hunger reduction efficiently. The reasons are obvious: first, poverty reduction takes time and the hungry need immediate relief; second, by contrast to many diseases for which cures are either unknown or unaffordable, the means to feed everyone are readily and cheaply available; and third, hunger is as much a cause as an effect of poverty. Unless hunger is reduced, progress in cutting poverty is bound to be slow. Hunger reduction is therefore a means to enhance productivity directly and swiftly. The benefits are equally obvious: better-fed people are more productive workers, better-fed children are more attentive pupils and better fed women are healthier mothers who give birth to healthier children and can feed them better. The proposed programme therefore focuses not only on investments in agriculture and rural areas but also includes measures that ensure adequate and direct access to food. It aims to meet the needs of the most nutritionally deprived people in the world with an overall envelope of USD 7.5 billion annually.

As discussed in Chapter 23, various instruments could be used to channel enough food to the most needy. Proven options include:

- *Targeted direct feeding programmes*. These include school meals, feeding expectant and nursing mothers as well as children under five through primary health centres, soup kitchens and special canteens. Such schemes contribute to human resource development by encouraging children to attend school and improve the health and nutritional status of mothers and infants. They minimize nutrition-related illnesses and mortality among children, raise life expectancy and contribute to a fall in birth rates.
- *Food-for-work programmes*. In many developing countries, a significant number of rural people are subsistence or below-subsistence farmers, producing only enough food to feed their families for part of the year. Food-for-work programmes provide support for such households while developing useful infrastructure such as small-scale irrigation, rural roads and buildings for rural health centres and schools.
- *Income-transfer programmes*. These can be in cash or in kind, including food stamps, subsidized rations and other targeted measures for poor households, and are also a good means of increasing food-purchasing power and improving dietary intake.

Table 27.5: Investment in food safety nets			
Region	Baseline	Zero hunger	Increment
	Annual investment		
	million USD		
Developing countries	1 854	9 327	7 472
sub-Saharan Africa	551	3 374	2823
Near East/North Africa	68	442	374
Latin America/Caribbean	94	351	257
South Asia	731	3 732	3 001
East Asia	409	1 428	1 018

The costs of food safety interventions, including procurement, delivery and administrative costs are estimated to be an average of USD 40 per undernourished person leading to a total cost of USD 1.85 billion under the base line projections. This would need to be raised drastically to USD 9.3 billion (or an increase of USD 7.5 billion) to achieve zero hunger by 2025.

Productive safety nets

The need to make progress fast requires taking measures that ensure quick productivity gains for smallholders to raise output. Improving the performance of small farms in poor rural and peri-urban communities offers one of the best and most sustainable avenues for reducing hunger by increasing the quantity and improving the quality of locally available food. It also provides a foundation for equitable economic growth. At the very least, better performance improves food availability and nutrition within the immediate farm families, thereby increasing their capacity to enjoy a full life, learn and work effectively and contribute to the general good of society. It also increases and diversifies food supplies in local markets, creates a base for expanding and diversifying farm output into tradable products, opens employment opportunities and slows rural-urban migration.

The need to produce progress fast explains the massive scale of the proposed programme. Only a large-scale programme can have a meaningful impact on reducing hunger and poverty. Starting up such a process requires an initial injection of capital, either through loans or matching grants, to enable small farmers to build up productive assets on their farms. The average cost of investments required to kick-start a sustainable process of on-farm innovation may be estimated at about USD 600 per family. Typically, this start-up capital would finance the uptake of new technologies, such as improved seed varieties, plants, manure or fertilizers, small-scale on-farm works and equipment (e.g. land levelling, treadle pumps), breeding stock (e.g. poultry, goats) or contributions towards community-led measures to improve food security (e.g. school gardens, paralegal services to broaden land access). To ensure sustainability, farmers who take part in such programmes would repay the initial capital into savings and loans associations or community-run revolving funds, thereby allowing reinvestment of the benefits accruing from higher production.

Success in on-farm development depends on the creation of a policy environment conducive to agricultural growth, supported by research and extension institutions

responsive to locally-articulated needs. In many cases, success also depends on developments beyond the farm boundary, such as improvements in roads or in the supply of irrigation water. The investment needs for these improvements are addressed under other programme components.

Sustaining and upscaling this process requires the emergence of self-reliant community institutions that can take the lead in ensuring the food security of all their members, plough gains back into new investments and develop linkages with other communities through sharing knowledge and experience. This enables groups of communities with a common goal to place increasingly effective demand on the broadening range of services and types of infrastructure required to allow them to develop greater resilience to economic, social and natural shocks as well as to earn more and emerge from hunger and extreme poverty. The need to produce progress fast also explains the massive scale of the proposed programme (USD 2.9 billion). Only a large-scale programme can have a meaningful impact on reducing hunger and poverty.

Pillar 2: Investments in agriculture and rural areas

Public research and development (US$ 2.2 billion)

Probably the single most important contribution to the reduction of global hunger in the past has come from early and far-sighted investments in agricultural research and technology. While developed countries had recognized the power of public R&D investments in agriculture for more than a century, the breakthrough in developing countries only arrived with the creation of the CGIAR and its International Agricultural Research Centres (IARCs). Today, the success of these investments has become manifest in many ways. Global agricultural production increased by almost 150 percent since 1961, while over the same period the world's cropland base has increased by merely 14 percent, from 1.4 billion ha to 1.56 billion ha. At the same time, per capita calorie availability in developing countries has increased from 1960 per person per day in 1961/63 to 2620 in 2003/05, while the prevalence of hunger has declined from 34 percent in 1970 to 16 percent in 2003/05. Equally important has been higher productivity, helping raise incomes of millions of farmers and whole rural areas and keeping real food prices low for decades.

Things have changed recently and they have changed abruptly. Food and energy prices spiked in 2006-08 and, directly following this spike, a massive economic downturn that engulfed developed and developing countries alike took a heavy toll on the poor and hungry. Preliminary estimates suggest that the combined effect of higher food prices and economic crisis has pushed the number of undernourished above the one billion mark. The crisis has also affected urban areas, thus underlining that hunger and poverty reduction cannot rely solely on promoting the absorption capacity in manufacturing and services but must begin in agriculture and rural areas. And finally, high energy prices and a growing use of agricultural resources for the energy sector underscores that agriculture may have to cater to more than just the food market in the future. In a future with high energy prices, a growing share of agricultural produce will become competitive for the vast energy market, a market that could absorb much of the incremental agricultural production in the future.

While these developments suggest that research needs have become larger and more complex, investment in public R&D have been levelling-off overall and, in some regions, they have even declined. Since the late 1970s, when most regions still enjoyed high growth rates in R&D investments, expenditures have slowed considerably. For developing countries as a whole, growth in R&D expenditures slowed from three percent *per annum* in the 1980

Table 27.6: Investment in research and development

	Baseline	Zero hunger	Increment
	Annual investment		
	billion USD		*million USD*
Developing countries	42.1	44.2	2 180
sub-Saharan Africa	3.8	4.3	435
Near East/North Africa	3.6	3.7	77
Latin America/Caribbean	7.8	8.1	343
South Asia	7.9	8.8	902
East Asia	18.9	19.3	422

to merely 1.9 percent *per annum* in the 1990s and even less in the 2000s. While expenditure growth remained relatively high in the Asia-Pacific, Near East and North Africa region, public R&D expenditures started to slow already in the 1980s in sub-Saharan Africa and even declined by 0.2 percent per annum in the 1990s. Preliminary estimates suggest that the trend to lower R&D in Africa continued unabated in the 2000s. At the same time, public R&D expenditure has become more concentrated, with China (Mainland), India and Brazil now accounting for 43 percent of this total compared with 35 percent in the early 1980s.

The exact effect of this slow-down in public R&D expenditures is difficult to gauge, but there is ample and cross-sector evidence that it inescapably results in lower productivity growth and eventually in higher real prices for food. Making matters worse recently is that donors have identified more and more goals without raising the overall investment envelope for R&D. This has created increasing and competing demands without increasing the resources. Research for nutritional improvements or environmental benefits for instance have siphoned off funds for productivity improvements. And high yields for wheat and maize in developed countries distracted from badly needed investments in productivity enhancements for many crops in the marginal production environments of developing countries.

Public R&D expenditures therefore must rise again to meet the food and fibre needs of the future. To achieve zero hunger by 2025, developing countries' expenditures will have to rise by USD 2.2 billion annually (Table 27.6). This assumes R&D investment needs of USD 28 to 30 per USD 1 000 increase in value of agricultural output. It does not yet include R&D needs that may arise from climate change adaptation or the potentially huge market for bioenergy. Nor does it include R&D needs to finance maintenance research for the time horizon beyond 2025.

Broken down by region, South Asia would account for over 40 percent of the incremental USD 2.2 billion dollars, reflecting both its large agricultural base as well as the region's high current number of undernourished people. The second highest increment would need to be allocated to sub-Saharan Africa, the region that needs to make the fastest progress in reducing the prevalence of hunger (Table 27.6).

Refocus R&D to the needs of the poor: Two factors are crucial for determining the kind of research needed to achieve the zero hunger goal: (i) it must be targeted to the production environments of the poor; and (ii) it must render results fast. Targeting to the poor means focusing on smallholder agriculture, subsistence and semi-subsistence farms; it implies a particular emphasis on orphan crops, marginal/fragile agro-ecological environments and on a production package that is typically characterized by low capital and high labour intensity. Table 27.7 provides an overview of pro-poor research needs for a wide range of crops, differentiated by biotic and abiotic stress factors.

Re-organize R&D funding and architecture: To avoid under-funding from threatening the survival of existing R&D systems in developing countries, policy-makers must find alternative institutional mechanisms for sustained financing. While some alternative mechanisms have been tried in many countries, the full repertoire of possibilities is far from exhausted. They include joint public-private sector ventures, sale of research products, competitive funds, research foundations, farmer managed levies on production and greater involvement private sector research. Also, universities in developing countries are an underutilized resource that could greatly increase research output with small incremental funding. Research foundations present another alternative to the public sector for providing funding and/or implementing agricultural research. Because the boards of directors of these research foundations usually consist of representatives from the private sector, they often base their research priorities on market demands and therefore provide an important link between the public and private sectors. And finally, while the private sector also offers a considerable potential to boost funding and efficiency of the global agricultural research system, its actual involvement in developing countries' R&D remains fairly small. Ninety-four percent of private sector executed agricultural research is conducted in high-income countries.

The need to deliver fast production increases also means that R&D expenditures cannot be allocated only to science & technology or basic research. The gestation periods of investment in basic research are simply too long to produce substantial results prior to 2025. Instead, the programme requires refocusing overall R&D expenditures from basic research to technology transfer and applied research (e.g. research to turn breeding lines from IARCs into new varieties at the extension and farm level). It also requires much greater expenditures on extension.

Extension (US$ 4.1 billion)

Data on extension expenditures are notoriously difficult to come by and there is no straightforward formula that links needed extension expenditures directly to R&D expenditures or targeted production levels. Experience from individual countries suggests that every dollar spent on R&D should be matched at least by another dollar spent on extension, albeit with large regional differences.

The need to step up production fast in often marginal production environments means that R&D efforts need to be accompanied and indeed preceded by more funds for extension. Long gestation periods between committing R&D funds and practical success on the ground and the quick returns from transferring and adapting existing technologies have motivated the relatively high amounts to be spent on extension. Aggregated over all developing countries, the zero hunger scenario would require about USD 4.1 billion to be allocated to extension services (Table 27.8). Particularly strong is the need in sub-Saharan Africa expenditures where the initial extension expenditures are particularly low and where the catch-up process would be most pronounced.

Table 27.7: Investment in extension			
	Baseline	Zero hunger	Increment
	Annual investment		
	billion USD		*million USD*
Developing countries	74.5	78.7	4 132
sub-Saharan Africa	11.5	12.8	1 304
Near East/North Africa	7.2	7.3	154
Latin America/Caribbean	15.6	16.3	687
South Asia	11.9	13.3	1 354
East Asia	28.4	29.0	633

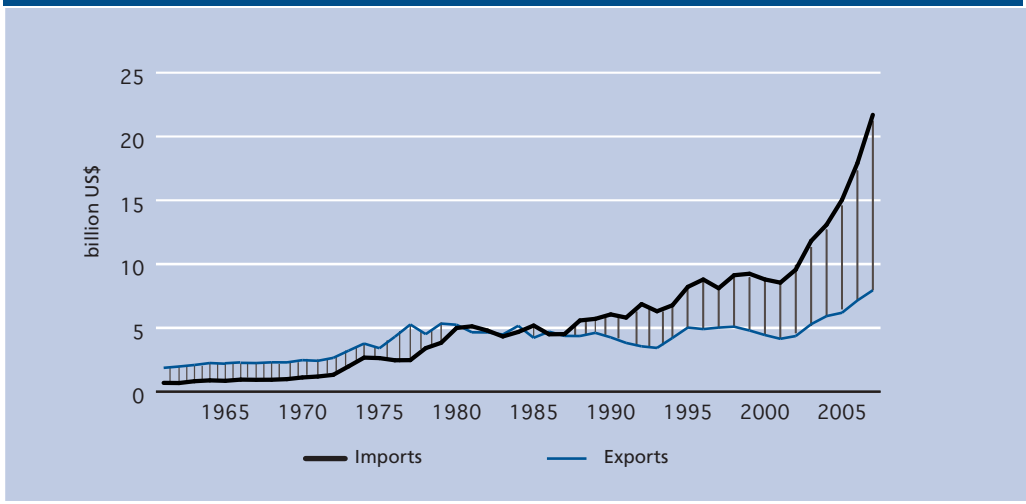
Rural infrastructure (US$ 18.5 billion)

One of the key deficits holding back agricultural development in many developing countries is a profound absence of basic infrastructure. Insufficient transportation systems raise costs for farm inputs and lower farmgate prices for agricultural produce. Insufficient storage exposes farmers to high losses and compromises the quality of their produce. As long as transport is difficult and expensive, electricity unavailable or unreliable and storage inadequate, a productive and profitable agricultural sector remains an elusive goal. Improvements to major infrastructure - particularly rural roads and railways, rural electrification and storage - are therefore the key way out of this impasse. Finding practical means of breaking the infrastructural bottlenecks is therefore a high priority of this programme, and explains the high overall expenditures for infrastructure of USD 18.5 billion annually (Table 27.9).

The USD 18.5 billion comprise a whole range of different investment areas, ranging from rural roads to electrification to cold and dry storage and more. While the estimates for these investment areas will be presented individually, it should be noted from the outset that the various investment areas are highly interdependent and interlinked. Considerable synergies can be had when infrastructure measures are implemented as a comprehensive and consistent package. Investments in cold storage, for instance, require reliable and sufficient rural electrification to be viable. Likewise, investments in milling facilities must be planned with adequate dry storage, electrification and feeder roads. Roads, storage and milling together help establish a processing and transportation chain with minimal losses.

Rural roads (US$ 8.2 billion): The fundamental importance of investing in rural roads lies in its vast potential to reduce transaction costs between farms and urban markets. Rural roads, pathways and, where appropriate, railways lower transportation costs to urban areas and allow farmers to fetch higher farmgate prices for their produce. By shortening transportation time, better rural transportation also helps improve the product quality and reduces losses. At the same time, lower transportation costs reduce prices for inputs, notably fertilizer, feedstuffs, power or pesticides and allow farmers to step up production intensity and use their resources (land, water, labour) more fully and efficiently.

Figure 27.4: LDC Imports and exports of food and agriculture: 1961-2007



Source: Authors.

High transaction costs matter vastly in many developing countries. For instance, it costs only USD 40 to ship a tonne of fertilizer 9 000 km from the United States of America to coastal Mombasa, while it costs another USD 120 to take it from the port to Kampala, a distance of 500 km. The same high transportation costs apply for bringing a tonne of millet, sorghum or other produce from the farm to the consumer in urban areas or the ports at the coast. The high shipping costs for inputs have the same effect as a high import tariff, i.e. a tariff on fertilizer, feedstuffs, seeds, or diesel. These high transaction costs make inputs expensive for farmers and help explain the very low fertilizer and plant protection applications levels and ultimately very low yields in sub-Saharan Africa. On the output side, high transaction costs work like an export tax, squeezing profit margins for farmers and lowering the competitiveness relative to foreign farmers.

Expensive inputs, high shipment costs and high losses from farms to markets have undoubtedly lowered the competitiveness of domestic agriculture in many developing countries. At the same time, foreign suppliers have benefited from subsidies in the exporting markets and a transformation of the retail sector in the importing countries that resulted in a growing prevalence of higher foreign standards. These factors contributed to the growing trade deficit of many developing countries. The least developed countries (LDCs), i.e. the 50 poorest developing countries, have been hardest hit; their net imports of food and agricultural products have soared over the past 20 years (Figure 27.4) to a level of nearly USD 14 billion by 2007.

Investment in infrastructure pays off handsomely: Not all developing countries have neglected their rural infrastructure, and those who invested have reaped considerable rewards. Particularly countries in East Asia have invested substantially in rural roads and transportation facilities. China (Mainland), for instance, has increased investments in rural roads from RMB 35.8 billion to RMB 124.2 billion from 2001 to 2004. In parallel, new

Table 27.8: Investment in rural roads

	Baseline	Zero hunger	Increment
	Annual investment		
	billion USD		*million USD*
Developing countries	24.3	32.5	8 194
sub-Saharan Africa	2.8	5.2	2 409
Near East/North Africa	3.5	3.8	244
Latin America/Caribbean	6.1	8.0	1 808
South Asia	7.1	9.8	2 710
East Asia	4.7	5.8	1 022

Source: Authors.

bridges, pathways and rural water supplies were built and by 2006, 62 percent of villages were connected to their towns by paved roads. At the same time, investments in rural water supplies helped improve access to clean drinking water. Between 2001 and 2004 alone, the share of villages with access to tap water rose by 15 percent. More recently, the stimulus package to counter the effects of the global financial crisis has supported further improvements in rural infrastructure, improving links both within rural areas and the connections to Mainland China's growing urban consumer base. Despite its scarce land and water resources and rapidly growing urban food market with its shift in consumption patterns, Mainland China's farmers have managed to feed the country with stapes largely from its domestic agricultural base.

The additional investment in roads to reach zero hunger have been estimated at nearly USD 8.2 billion annually (Table 27.8). These investments will help raise agricultural efficiency and provide the necessary infrastructure to ship more inputs to farms and more produce to the final consumer. A better rural road network will also raise farmgate prices, lower losses and improve quality. Moreover, it will create jobs and incomes in rural areas for the construction and maintenance of roads and thus contribute to rural higher incomes overall.

A breakdown of the total incremental needs of USD 8.2 billion by region shows that South Asia will absorb the largest share of the total with more than USD 2.7 billion incremental investments. This reflects both the region's large agricultural base but also its significant needs to catch up to more adequate levels of road infrastructure. Relative to the baseline levels, the largest increments are needed for sub-Saharan Africa where infrastructure investments would have to rise by the factor of 1.9 to USD 5.2 billion annually (Table 27.8) relative to the baseline levels. In large measure this is owed to its poor current infrastructure endowment and underscores the particularly high need to raise agricultural productivity to reach the zero hunger goal in that region.

Rural electrification (US$ 4.1 billion): Not only rural roads but also rural electricity grids are unavailable and unreliable in many hunger-stricken countries. For instance, only 5 percent of Africa's rural population has access to electricity, while the rest depends on traditional fuels such as wood and manure for cooking, heating and light. In South Asia electricity consumption per person is the lowest of all regions. An inefficient power grid and obsolete

Table 27.9: Investment in storage, marketing and processing

Region	Annual investment		
	Baseline	Zero hunger	Increment
	billion USD		*million USD*
Developing countries	104.7	110.4	5 681
sub-Saharan Africa	10.2	11.5	1 282
Near East/North Africa	10.8	11.0	239
Latin America/Caribbean	22.4	22.9	487
South Asia	24.8	27.5	2 724
East Asia	36.6	37.5	948

equipment result in power losses that are 30 percent higher than in developed economies. Although empirical data for separate estimates for rural and urban infrastructure are hard to find, evidence based on household surveys points to a clear "infrastructural disadvantage" of rural areas relative to urban ones. It also points to a particular disadvantage of African and South Asian households as compared with those in other regions.

Upgrading and expanding rural electrification necessary to support the expansion of irrigation, processing and storage facilities in rural areas was estimated to amount to USD 4.1 billion annually. Sub-Saharan Africa and South Asia would have the largest investment needs, absorbing USD 1.2 and USD 1.4 billion per year respectively for investments in rural electrification.

Storage, marketing and processing (US$ 5.7 billion)

FAO estimates suggest that post-harvest losses alone account for 25-40 percent of total agricultural production in developing countries. Losses can even be higher for individual countries and individual crops particularly when bumper harvests yield output well in excess of the limited storage capacities. Building or improving storage facilities to reduce these massive losses is therefore an important element of this programme.

While reducing high losses is an important achievement in its own right, the benefits of better storage exceeds the mere reduction of production losses. Reducing losses ultimately means reducing pressure to raise output, and thus means fewer inputs such as fertilizer, seeds, power, or pesticides. It also means reduced pressure on natural resources, with less need to farm marginal land, forests, swampland and other precious habitats or to tap into scarce water resources. Better storage also provides a buffer for production shortfalls and thus helps reduce swings in market prices for farmers and consumers. And finally, adequate storage maintains the quality of farm produce, helps enhance food safety and thus allows farmers to fetch a higher price. These extra benefits can be further augmented if more and better storage is matched by investments in processing facilities and marketing chains. The integration of storage, processing and marketing activities is at the heart of the idea to build-up value chains and the efforts to allow farmers to reap a larger part of the final consumer expenditures. These expenditures can reach, depending on product and country, multiples of the amounts received by farmers for the primary product.

For developing countries as a whole, the necessary investments into better storage, processing and marketing have been pegged at annual amounts of USD 5.7 billion (Table 27.9).

Even a cursory inspection of the allocations in Table 27.9 reveals pronounced regional differences with the lion's share of the incremental needs allocated to South Asia and sub-Saharan Africa. This is not an unfamiliar pattern and reflects, in essence, the particular efforts needed to reduce hunger and the inadequacy of current storage and processing facilities in these two regions.

Development and conservation of natural resources (US$ 9.4 billion)

Food production, more than any other form of economic activity, relies on productive natural resources. The resource base for food production is nearly all-embracing, including cropland and pastures, forests and plantations, oceans and fresh water, as well as plant and animal genetic resources. The need to raise food production means that these resources must be used more intensively in the future and thus poses an increased risk for their degradation or complete destruction. Wind and water erosion can degrade fertile land, excessive irrigation depletes aquifers, ill-designed drainage systems result in water-logging and mono-cropping reduces soil fertility and ultimately destroys the genetic resistance against pests and diseases. Appropriate technologies, skilled labour, infrastructure and institutions in turn enhance their productivity and ensure that they can be used sustainably. This requires investments in sustainable production methods, efforts to preserve genetic resources and biodiversity and in skills and training to manage the resource base in a sustainable manner.

The annual incremental investments to develop and conserve natural resources have been estimated to amount to USD 9.4 billion of which USD 3.6 billion per year is needed for the extension and improvement of irrigation systems beyond the farm boundary (e.g. dams, canals) and the implementation of programmes that foster farmers' adoption of soil and water conservation practices. USD 600 million per year would be needed to conserve and use plant genetic resources. This would support international and national activities necessary to conserve, evaluate, make available and enhance the use of plant genetic resources, providing the basis for yield increases through crop breeding and better on-farm management of genetic resources.

The conservation of farm animal genetic resources, together with genetic improvement schemes for increased animal productivity through higher reproductive rates and better production per animal would require additional investments of USD 460 million per year.

Ensuring the sustainable use of the world's fisheries, while increasing production will require investments of an additional USD 2.4 billion per year in fisheries monitoring and protection and for the creation of alternative livelihood sources for fishermen and in aquaculture. As most wild fish stocks are fully exploited, about 70 percent of these investments will be used to conserve aquatic ecosystems and manage associated capture fisheries. Additional fish demand will be met mainly from aquaculture, in which relatively modest public investment will trigger large private investment commitments.

Incremental public sector investment needed to use forests in a sustainable manner is estimated conservatively at USD 2.4 billion per year. This would be used to protect forests from unauthorized or unplanned conversion, manage wild food sources in forests, develop alternative livelihood opportunities for food-insecure forest-dependent populations and minimize and offset the negative consequences of converting forest to agricultural land.

Building and expanding rural institutions (US$ 5.6 billion)

Institutions make investments work. Building and expanding support for institutions is needed in many areas, particularly for ensuring a functioning rural finance system,

effective research and extension systems, guaranteeing land titles and tenure security or promoting rural mechanization. These demands have rapidly grown over the past decades while institutional capacities have stagnated. Many inefficient public institutions have been destroyed in the course of structural adjustment programmes but have never been replaced by more efficient ones, neither public nor private. This has left a huge institutional void in many developing countries, particularly in sub-Saharan Africa, and explains the significant requirements for a better institutional environment. Overall, the needs have been estimated to add up to a total of USD 3.6 billion annually.

Institutions are also at the heart of creating new and strengthening existing absorptive capacity for investments. Provided that an appropriate legal and regulatory framework is in place, the institutions ensure that investments are allocated efficiently. For instance, new research and development funds can only be allocated efficiently if an institutional infrastructure exists that helps transfer new technologies and know-how from research centres to experimental stations to the farm. And, to ensure that the newly-generated benefits can be shared by the poor, improved and expanded extension services are inevitable. Likewise, enhanced mechanization requires institutions that provide quality assurance, consumer (farmer) safety and vocational training for farmers and operators to be fully effective. Institutions are also critical for establishing formal property rights or for creating legal titles to land and other assets, which is, in turn, a necessary precondition to establish collaterals for much-needed loans. Indeed, most important in the context of this investment programme is that a functioning rural finance infrastructure ensures that the proposed capital flows can be channelled efficiently and without major "losses" to the final investment destination.

Rural finance (US$3.6 billion) The lion's share of the overall funds required for building or rebuilding institutions will be absorbed by the creation and deepening of the rural finance infrastructure necessary to channel the proposed funds into rural areas. In many countries, particularly in sub-Saharan Africa, there is a need to build a functioning rural finance system from scratch.

The first challenge for the rural finance infrastructure will be channelling the additional USD 42 billion for rural and agricultural development efficiently into rural areas; if implemented successfully, these public funds are expected to crowd-in private investments that could reach three or four times the volume of the initial public investments. In addition, there is the need to establish or strengthen appropriate fiduciary systems that ensure that proposed investment flows are reaching their stated destinations, and that their performance can be monitored, controlled and audited. The costs for building up the rural finance infrastructure and the related fiduciary systems are difficult to gauge and the underlying calculations are based on rough rules of thumb rather than precise parameters. What is more, the extent and efficiency of the existing finance infrastructure varies widely from country to country, ranging from extensive coverage in many Asian economies to a virtual absence in many sub-Saharan African countries. Assuming additional overall annual public investments of USD 42 billion and incremental costs between 5 percent (East Asia) and 20 percent (sub-Saharan Africa) of the investment flows to establish a new or expand an existing rural finance infrastructure, the creation and operation of the rural finance sector needed for this programme would amount to USD 3.6 billion annually.

The high additional investment costs are also a reflection of the particular challenges facing developing countries' rural finance systems in general. These include high transaction costs associated with dispersed populations and the seasonality of household income flows,

which typically peak at harvest time but fall away at other times, making credit repayment which is not tied to seasonality factors a challenge for poor households. Other problems include a lack of collateral owing to a widespread absence of clearly defined property rights as well as insufficient or completely missing cadastre and land title systems. Even where land titles exist, they are seldom transferable and so cannot (or not easily) be used as collateral. The situation is particularly serious in much of sub-Saharan Africa where a combination of high production risk, scarce borrower information, cumbersome legal procedures and high transaction costs means that many financial service providers are reluctant to serve poor farmers and business people, leaving the market open to informal institutions and operators like traders and processors who may well be less scrupulous and supportive in the way they operate.

This context provided the rationale for the state subsidized and targeted agricultural finance schemes that flourished in the 1970s and 1980s but which, with a few exceptions, turned out to be rather ineffective and inefficient. By contrast, microfinance programmes (credit, savings and, to a lesser extent, micro-insurance and leasing services) have been more successful; they have proven effective in creating access to small loans and helping reduce poverty in rural areas. Given the typically small size of loans and the short repayment periods, microfinance schemes have been particularly important and successful in financing working capital and items with short depreciation periods (while they are less important for financing long-term investments). Investments in capital goods of longer life spans and larger amounts require a broader range of different rural and agricultural finance institutions, including rural credit unions, specialized development banks or rural finance co-operatives.

Institutions for tenure security and secure land titles (US$ 0.8 billion) The rationale for investing in land title and land tenure institutions is twofold: first, there is considerable catch-up potential for improvements seeing as insecure land tenure is pervasive in most developing countries; and second, systems that ensure formal ownership titles are often missing.

At the same time, the benefits possible from improved tenure security and formal ownership rights are manifold: (i) ownership rights and tenure security are the basis to use land as collateral for investments and thus allow farmers and tenants to gain access to formal credit markets; (ii) secure tenure and ownership is also a necessary precondition for the adoption of sustainable farming practices, for long-term investments in land conservation and erosion control; (iii) secure titles and tenure help farmers reduce the amount of resources needed to defend the access to land (empirical evidence suggests that this is a particularly beneficial for smallholders, who can save considerable amounts of resources and spend more time in local labour markets thus significantly improve their non-farm incomes); and (iv) secure land titles lower transaction costs or, in any case, make transactions possible at all (this allows smallholders who decide to leave their farm to sell the land or receive compensation in the case of expropriation; likewise, secure tenure rights allow them to return to their plots and enable them to seek temporary jobs in urban areas). These benefits suggest that institutional investments in secure land and tenure rights are a necessary precondition for the considerable investments proposed in land conservation and the protection of natural resources.

The overall investment requirements to establish new and enhance existing land title and land tenure systems have been estimated at USD 0.8 billion annually. In principle, these investments comprise two components: first, establishing land registers, cadastre systems and enacting the legal code that allows to establish and enforce property rights; and second,

creating the relevant institutions as such, ensuring that they have universal outreach to cover remote areas and establishing the legal framework needed to enforce property and tenure rights and to interpret these rights so that possible conflicts are avoided from the outset.

Institutional needs to promote rural mechanization (US$ 1.2 billion): The baseline investment projections to 2030/2050 suggest that mechanization will be the single most capital-intensive investment area, absorbing one third of all capital needs of primary agriculture over the next four decades. These investments include a whole range of different items, notably tools, tractors, implements, combines and many other forms of farm equipment and machinery. Clearly, much of the capital needs for mechanization will have to come from private sources. Farmers themselves must decide on the extent, type and timing of such investments on the basis of the promised returns. On the face of it, a role of the public sector is therefore hard to discern. In fact, subsidies for mechanization could even lead to overinvestment and ultimately to a misallocation of private and public capital.

There are, however, factors that can result in a marked underinvestment in mechanization or unduly stifle the profitability of private investments particularly for smallholders. For a small farmer, purchasing a tractor or even a simple tool or implement is often a highly capital-intensive exercise and individual holdings are generally too small to provide the scale that would be required to reduce fixed costs for a profitable investment proposition. Even where such investments are profitable, the liquidity requirements for these big capital items can be too demanding to make the investments viable in practice. To overcome these constraints, the zero hunger scenario assumes public support of about USD 1.2 billion in two distinct areas:

Building and re-building institutions for mechanization

The crucial importance of rural financing institutions has been discussed. The important elements include a range of measures such as cadastre systems, clearly defined land and property rights and the operation of rural finance institutions as such. It should suffice here to underline that they are particularly important for capital-intensive investments such as mechanization and that public expenditures to establish these institutions have already been accounted for.

Not accounted for but also important are the benefits that can be provided by mechanization-specific institutions. For individual countries, they include the organization and operation of tractor-hire and tool-hire schemes, schemes to promote group ownership, machinery-hire services and start-up assistance for private service providers. A growing mechanization of agricultural production will ultimately also require growing expenditures for vocational training, farmer field schools, training courses for farmers and operators of equipment. On a regional basis, important benefits will come from regional testing centre and rural mechanization lead clusters (RMLC). RMLCs have played and important role in the mechanization of Asia's agriculture, particularly in providing quality assurance to farmers, importers and distributors of equipment, client (farmer) safety and protection as well as market intelligence and transparency. The provision of such services and schemes will also be important for successful mechanization in other regions, particularly in sub-Saharan Africa. The zero hunger scenario assumes that requirements to establish and run these mechanization institutions will amount to about 8 percent of the overall capital needs for mechanization. This share should suffice to establish and run both national and regional mechanization schemes and institutions.

Table 27.10: Pro-poor R&D priorities in plant breeding

Crop	Biotic stress factors		Abiotic stress factors	
Wheat	Disease: Leaf and stripe rusts; Fusarium head blight, powdery mildew and Weed competition	insects: Hessian fly and weevils	Heat	Drought
Maize	Weed competition	Insects: stem borers, including storage grain insects	Low soil fertility	Drought
Cassava	Disease: (Cassava mosaic virus, Cassava brown strike diseases, Cassava bacterial blight) and insects (Mealy bug, Mites and Trips)	Weed competition	Low soil fertility	Drought
Rice	Disease: (Leaf blast, bacterial Leaf blight, Sheath blight, Bacterial leaf streak) and virus (rice tungro and Rice Yellow Mottle Virus)	Insects: Brown plant hopper, Stem borers, Gall midge	Drought, Heat and cold	Flood, Alkali and salt injuries
Sorghum	Disease: anthracnose, grain moulds, leaf blight, rust, ergot, head smut, loose kernel smut, covered kernel smut, downy mildew, charcoal rot, maize stripe virus, maize mosaic virus, striga	Insects : sorghum shoot fly, spotted stem borer, sorghum midge, ear head bug, green bug, sorghum mites,	Drought, low temperature, high temperature, salinity, acidity, water logging, low soil fertility	
Pearl millet	Disease: downy mildew, ergot, smut, blast, rust, striga	Insects : white grubs, shoot fly, stem borer, head minor, Helicoverpa, blister beetles	Drought, high temperature, salinity	water logging, low soil fertility
Pigeon peas	Disease: wilt, sterility mosaic disease, phytophthora blight, alternaria blight, collar rot, dry root rot, cyst nematode	Insects : Helicoverpa, pod fly, pod wasp, blister beetles, Maruca, pod bug, Lima bean pod borer, flower thrips, bruchids	Drought, soil acidity, salinity, water logging	
Chickpea	Disease : Ascochyta blight,sclerotium stem rot, botrytis gray mold, fusarium wilt, dry root rot, collar rot, stunt, nematodes	Insects : Helicoverpa pod borer, leaf miner, aphids, bruchids	Drought, low temperature, high temperature, salinity	Fe deficiency
Groundnut	Disease: early leaf spot, late leaf spot, rust, bacterial wilt, bud necrosis, nematodes, (A. flavous colonization, aflatoxin contamination- more of quality aspect)	Insects: white grubs, Spodoptera, red hairy caterpillar, Helicoverpa mites, jassids, aphids, thrips, leaf miner	Drought, salinity	Fe and Zinc deficiency
Barley	Disease: Net blotch, Powdery mildew, yellow and stem rust, Barley yellow dwarf virus (BYDV), Scald	Quality (malting and animal feed)	Drought	Heat and cold
Potato	Disease: Late blight P. infestans Virus(es) PVY, PLRV Bacterial wilt R. solanacearum	Insects: Leaf miner fly Colorado potato beetle Potato tuber moth, cyst nematodes	Heat/salinity	Drought; frost
Sweet potatoes	Disease: Sweetpotato virus disease complex (SPVD), Sweet potato feathery mottle potyvirus (SPFMV) and sweet potato chlorotic stunt crinivirus (SPCSV)	Insects: specie of weevil, Cylus spp.	Drought	Salinity

Limited and time-bound incentives for a sustainable mechanization of small farms

In addition to building the institutional basis for an efficient mechanization, smallholders can vastly benefit from support for an initial mechanization step. These payments should be time-bound and limited in amount and may be made contingent upon the purchase of equipment that ensures the adoption of good, i.e. sustainable farming practices and thus help create an implicit environmental service. Such implicit payments for environmental services (PES) could promote practices such as conservation farming and no-till systems instead of ploughing and traditional tillage, they would favour row-planting over broadcasting seeding practices, or support permanent control traffic farming and other techniques that help to enhance the sustainability of agricultural production and reduce the carbon footprint of agricultural production. The environmental benefits of no-till farming are immediately evident on fragile erosion-prone soils particularly in tropical regions. Equally obvious are the private benefits of a shift to sustainable farming practices for individual farmers. A shift from ploughing to no-till agriculture alone reduces the on-farm power needs between 50-70 percent; these benefits would also allow to limit the payments to an initial stage and to phase them out over time.

Conclusions

Hunger is above all a manifestation of poverty. Around 75 percent of the poor live in rural areas and many depend on agriculture for their livelihoods. They eke out a living on farms of often less than two hectares, work as small entrepreneurs or earn meagre wages in the agriculture-related processing, storage, seed or feedstuffs sectors. They are poor because they rely on too few and too unproductive assets. A profound and prolonged lack of investment in agriculture has restrained the overall productivity of the sector, sometimes to the extent that it no longer stands as a viable base for poverty reduction. A lack of investment has also reduced the ability of farmers to cope with price volatility. Moreover, the cyclical tendency of investment flows appears to have pronounced price peaks and troughs.

The twin-track approach of affording the vulnerable access to more productive resources and support by safety nets is the basic idea of this programme. The programme also promotes the adoption of more sustainable production methods and investment in the conservation of natural resources, institutions, infrastructure and job creation in rural areas outside of agriculture. It invests in people and physical assets alike; it addresses both the need to raise output and productivity and the need to improve the sustainability of production methods. Furthermore, given the impossibility to sequence public investments counter-cyclically, the programme suggests that public investment should be allocated in equal instalments.

If implemented, a natural corollary of the programme would be to lower the vulnerability of those most at risk from exogenous shocks, both weather-related and economic ones, especially those which lead to irreversible harm to societal systems and human capital.

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