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Centre for World Food Studies

Can We Feed the Animals?

The Impact on Cereal Markets of Rising World Meat Demand

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Content

Abstract

The paper argues that current international projections of meat and feed demand may underestimate future consumption patterns for mainly two reasons. First, their demand projections are based on income extrapolation with an assumed demand elasticity, and on expert judgment. Second, feed requirements per unit of meat are taken to be fixed. Instead, we propose a structural specification of meat demand, that accounts for the differences in income between households within countries as well as for the nonlinear shape of the meat demand schedule since the poor segments of the population tend to abstain from meat consumption until their income reaches some lower threshold, while rich consumers become satiated beyond an upper threshold. Regarding feed requirements, we distinguish between traditional feeding technologies based on grazing, household residuals and harvest by-products, and more intensive livestock technologies. We formulate optimistic and pessimistic projections on technological advances in feeding efficiency, carcass weights, and offtake rates. Our finding is that under the growth rates of per-capita income assumed in the commonly accepted projections, world meat demand will be significantly underestimated in the coming thirty years, especially during the first half of this period, even under optimistic assumptions on technological advances. The fast increase in the demand for meat will together with the tendency towards urbanization make it more difficult to expand the branch of animal husbandry that feeds on residuals and grass. This creates a strong pressure on cereal markets, especially to satisfy demand in Asia.

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Section 1
Introduction

World wide income growth causes meat demand to rise. Whereas in the recent past the Green Revolution made it possible to satisfy the rising human demand for cereals, the challenge for world markets in the three decades to come is to supply sufficient animal products, in particular meat, and hence for feed grains and concentrates (IFPRI, 1999). Various authoritative studies expect meat consumption and demand for animal feed to keep on growing at rates similar to those during the past decades of strong productivity growth (FAO, 2000; OECD, 2001; USDA, 2001; and FAPRI, 2001). These studies conclude that it is technically feasible to meet the challenge if adequate efforts are made, and that this will not cause world prices to rise significantly (IFPRI, 1999; 2001).

Over the past decades, commodity projections for agricultural markets have systematically tended to overestimate future demand and to underestimate the scope for productivity increases. Consequently, their recurrent prediction of rising world prices was time and again refuted by the factual evidence of persistently falling real prices for food (Deaton and Miller, 1995). Developed countries currently see agricultural surpluses rather than shortfalls as their major problem, and the reference to Malthusian scenarios has lost credibility in view of the impressive successes achieved in feeding the world population, especially in East Asia. It seems that the agencies dealing with the issue have by now learned from experience and no longer predict shortfalls. However, this might obscure important issues such as the effect of high growth rates in per-capita income in recent years, in particular in some Asian economies, that have already caused significant shifts in demand towards food of animal origin (IFPRI, 2001; Mitchell et al., 1997). Thus, with per-capita income continuing to grow, a pressure on the demand side builds up that requires vast increases in the availability of animal feed. Hence, even though feeding the poor obviously remains the fundamental issue, on world food markets the relevant question has become whether we can feed the animals, rather than the people.

The studies mentioned base their projections on income extrapolation with an assumed demand elasticity, and on expert judgment. From this, feed demand is derived under fixed or slowly falling requirements per unit of meat. The motivation for this paper is to show that under the assumed growth in per-capita income, this can lead to a significant underestimation of future demand for meat and cereal feeds. We argue that this is due to two mechanisms. First, per-capita demand for meat depends primarily on per-capita income. Hence, the differences in per-capita incomes must be accounted for. Furthermore, the relationship is nonlinear as the poor segments of the population tend to abstain from meat consumption until their income reaches some lower threshold, while rich consumers become satiated beyond an upper threshold. Regarding feed requirements, we distinguish three types of feeding technology (based on pure grazing systems, intensive feeding or a combination, the mixed system) and develop assumptions how to adjust, per region, the shares of the three systems, as a response to the increased meat demand. In addition, as production shifts from small-scale backyard units to large commercial enterprises, the share of cereals in feed increases.

With IFPRI (2001) and FAO (2000) as reference, and disregarding price adjustments, we present alternative projections that include these two mechanisms. We find it important to consider both mechanisms for the following reasons. In countries with a relatively high average demand for meat a large fraction of the population may just have started consuming meat. In mid-income regions with favorable growth perspectives as in East Asia this will lead to a fast increase in demand. But even in regions such as South Asia with moderate growth perspectives the large number of people that hardly consumed meat before will also cause the growth rate of meat demand to be rising. Regarding feed requirements, the fast increase in the demand for meat will together with the tendency for urbanization make it more difficult to expand the traditional animal husbandry, with livestock roaming around the homestead.

As in FAO (2000) we do not present a full model with endogenous price and supply adjustment. But unlike these we do not try to balance supply with demand. Instead we merely evaluate demand for given developments in income and population, as our aim is to highlight the pressures emanating from the two mechanisms rather than to project future trends. To address the claim that technological improvements will balance the increases intensity of production, we formulate an 'optimistic scenario', where we allow for increases in carcass weights, offtake rates, and general improvements in feeding efficiency, and show that even under these assumptions, projected cereal demand exceeds by far the FAO (2000) projections. We also compare our results with the quantitative effects of other factors commonly deemed as key drivers for the future world food situation over the period under consideration and this leads to conclude that the effect on world markets of income-growth induced increases in demand is substantially larger than, for example, than those of advances biotechnology or climate change.

The paper is organized as follows. Section two derives an Engel curve for per-capita meat consumption, with minimum consumption and satiation levels, that is calibrated on the basis of both cross-country and time series data for meat consumption and income. We use this curve together with information on income distribution for all major countries to project meat demand under assumed rates of income and population growth. Section three projects the corresponding feed demand, where the composition of the production systems adjusts to reflect more intensive or extensive feed technology as a response to the increased meat demand. Section four concludes.

Section 2
Meat demand

We postulate a stylized, piecewise linear relation between per-capita meat consumption and disposable income — the Engel curve — with three different regimes as depicted in Figure 1. For per-capita income below a given threshold ($\underline{y}$), meat demand is low and hardly increasing, whereas it rises steeply at higher levels of per-capita income (between $\underline{y}$ and $\overline{y}$). Finally, when income exceeds $\overline{y}$, the slope of the Engel curve becomes low again, as satiation sets in. Obviously, such a relation implies that the Engel curve is convex increasing between the first and the second regime, and concave thereafter. In this section, we show that such a relation passes significance tests. Furthermore, we describe the implications of this S-shaped form in relation to income distribution and growth for the rise in aggregate meat demand worldwide.

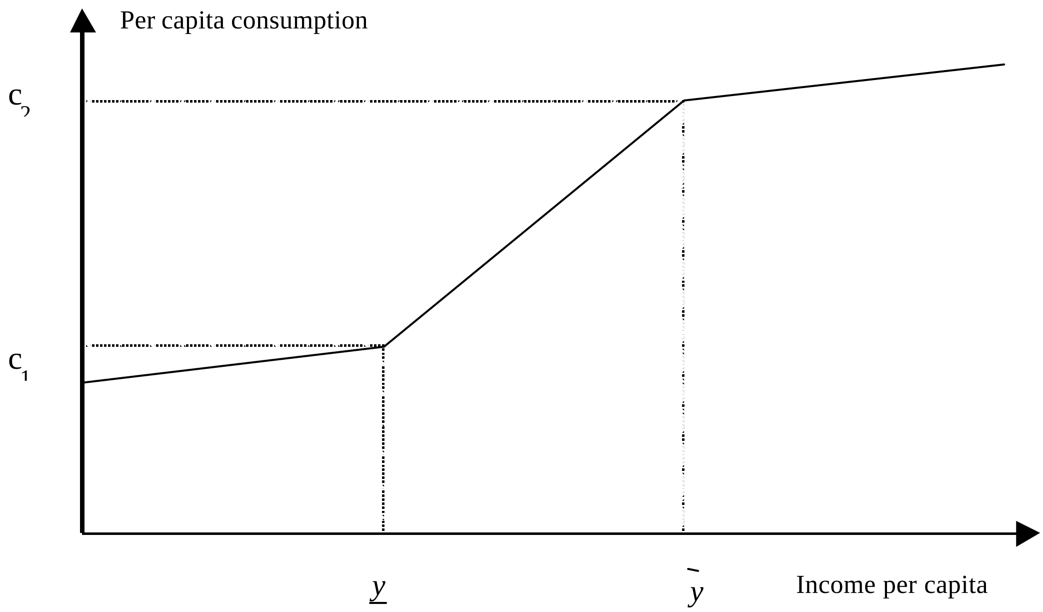

Figure 1. Engel curve for meat consumption

Yet we want to present the empirical evidence before postulating any functional form or thresholds. For this we use a non-parametric, kernel density regression (see e.g. Bierens, 1987). Figure 2 shows the results of such an estimation, based on the Mollifier program (Keyzer and

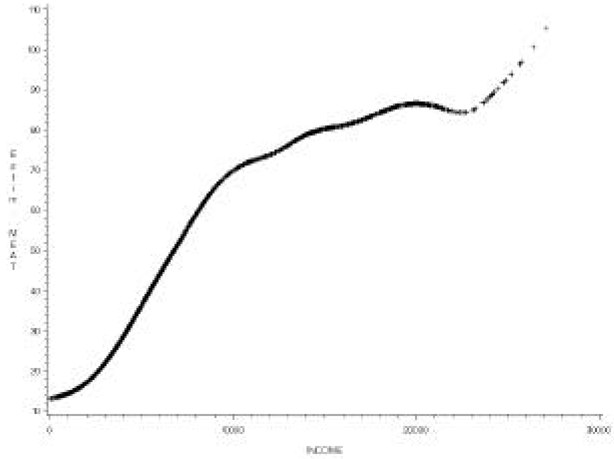

Figure 2a Non-parametric estimation of meat demand and per-capita income (1975-97)

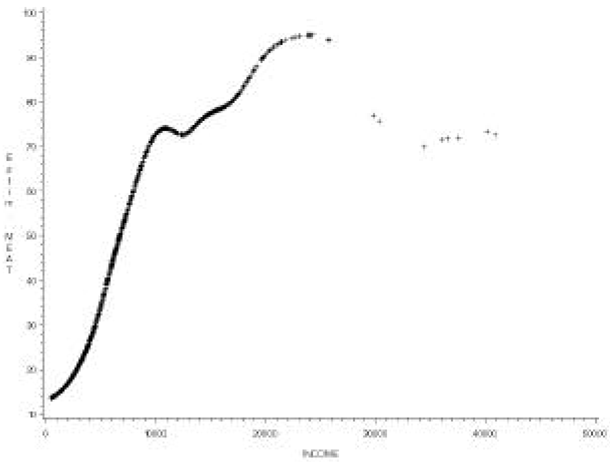

Figure 2b Non-parametric estimation of meat demand and per-capita income (1975-87)

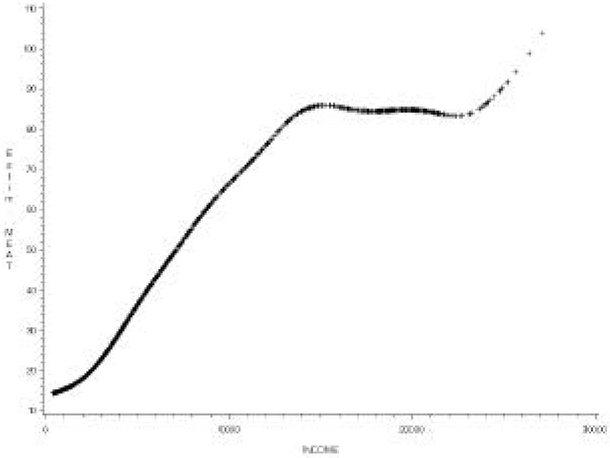

Figure 2c Non-parametric estimation of meat demand and per-capita income (1985-97)

Sonneveld, 2001) and cross-country data for 125 countries between 1975 and 1997.[1] To identify possible differences over time we also compare the results for the entire sample period (Figure 2a) with those for two sub-periods, from 1975 to 1987 and from 1985 to 1997 (Figure 2b and 2c). The curves confirm that the shape is relatively stable over time, and that the slope is indeed convex increasing at low levels of per-capita income, while exhibiting a tendency towards satiation at higher income levels. We note, however, that this is a cross-country relation that neglects the distribution effects within countries that are particularly important in view of the changes in slope. However, by considering a large number of countries at different stages of development, and without weighting for population size, we hope to detect sufficient variation for our estimations, as no data are available on the within-country distribution of consumption.

Next, we turn to a parametric estimation of the relationship between per-capita meat consumption and income. We specify per-capita consumption of meat in country i (c_i) as a piecewise linear demand function in terms of per-capita income (y_i):

$$c_i(y_i) = \begin{cases} a_1 + b_1 y_i\,, \ if & y_i \leq \underline{y}, \\ a_2 + b_2 y_i\,, \ if & \underline{y} \leq y_i \leq \overline{y}, \\ a_3 + b_3 y_i\,, \ if & y \geq \overline{y}, \end{cases} \tag{1}$$

where $\underline{y}$ and $\overline{y}_i$ are exogenous. Furthermore, coefficients satisfy

$$a_1 + b_1 \underline{y} = a_2 + b_2 \underline{y} \qquad \text{hence, } a_1 = a_2 + (b_2 - b_1)\underline{y}$$

and (2)

$$a_3 + b_3 \overline{y} = a_2 + b_2 \overline{y} \qquad \text{hence, } a_3 = a_2 + (b_2 - b_3)\overline{y}$$

After estimating the coefficients of such a demand function, we want to test the hypothesis that the slope b_2 of the mid-consumption regime is significantly different from b_1 and b_3. For this, we express b_1 and b_3 in terms of b_2 and two new coefficients, g_1 and g_3:

$$\begin{aligned} b_1 &= b_2 + g_1 \\ b_3 &= b_2 + g_3 \end{aligned} \tag{3}$$

Substituting (2) and (3) into (1) we obtain the following system of linear equations:

[1] Income is given in per-capita GDP in Purchasing Power Parity (PPP)-Dollar, deflated by the consumption price index in the USA in 1992 (source: The World Bank Indicators 2000). We further reconstructed data for split and merged countries, and omitted countries for which income or meat data was missing. Meat data is taken from FAOSTAT (2002).

$$c_i(y_i) = \begin{cases} a_2 + b_2 y_i + g_1 (y_i - \underline{y}), & \text{if} \quad y_i \le \underline{y}, \\ a_2 + b_2 y_i, & \text{if} \quad \underline{y} \le y_i \le \overline{y}, \\ a_2 + b_2 y_i + g_3 (y_i - \overline{y}), & \text{if} \quad y_i \ge \overline{y}, \end{cases} \tag{4}$$

Next, we extend system (4) by four country-specific dummy variables for China, India, the USA and Japan and estimate the coefficients for different levels of income thresholds ($\underline{y}$ and $\overline{y}$). Table 1 shows the results of a maximum likelihood estimation implemented as a weighted least squares (WLS) estimation of system (4), with a regime specific heteroskedasticity correction and iteration over $\underline{y}$ and $\overline{y}$ combinations until the best fit is found. We find all coefficients to be highly significant and to produce a sufficient fit of our estimation. In particular, we can not reject the hypothesis that the slope of the mid-regime is significantly different from that in the first and third regime, since γ-coefficients come out highly significant. Moreover, their negative sign confirms that the slope of the medium interval is steepest. Thus, as in the non-parametric regression, the parametric estimation supports the hypothesis that the Engel curve is convex increasing for low-income levels and becomes satiated thereafter. Furthermore, to test for changes in preferences, we include dummy variables for sub-periods to allow for shifts in coefficients but none of these shifts coefficients proved significant. If any, there appears to be a very modest and insignificant upward trend in the propensity to consume meat and definitely none towards a more vegetarian lifestyle.

Table 1. Parameters of the Engel Curve (WLS Regression at optimal thresholds)

Parameter	Estimate	Approx. Standard Error	t-ratio
a_2	-1.182*	0.60665	-1.95
b_2	8.07**	0.12878	62.64
γ_1	-4.82**	0.44422	-10.85
γ_3	-7.09**	0.23864	-29.70
Dummy 'China'	7.32**	1.37780	5.31
Dummy 'India'	-9.56**	1.30257	-7.34
Dummy 'USA'	23.81**	3.93967	6.04
Dummy 'Japan'	-50.37**	3.79094	-13.29

Income thresholds: $\underline{y}$ = 2200 US-$; $\overline{y}$ = 9700 US-$

Consumption thresholds: c_1=16.6kg/year; c_2=77.1kg/year

Number of observations	2875
R-squared	.6161
Adjusted R-squared	.6152

* indicates significance at the ten percent level
** indicates significance at the one percent level

To derive the implications for aggregate meat demand when individual per-capita incomes of the population are growing, we present a formal condition under which the S-shape of the individual demand curve translates into an S-shaped aggregate demand curve. We are specifically interested in charting out the time period in the future during which the aggregate demand will rise faster than income, i.e. have an elasticity larger than unity, because of the convexity. By contrast projections by FAO (2000) and IFPRI (2001) rely on elasticities of less than unity.

While we have access to income distribution data for a reference year,[2] information on the distribution of consumption is lacking and so is data on the change of income distribution over time. Hence, we need to make an assumption on the relationship between individual and average per-capita income. We initially assume, as in FAO (2000), that both are equal, i.e. that all individual incomes grow at the same rate, regardless of their initial level. This amounts to keeping the income distribution constant relative to the mean per-capita income. Then, individual income can be expressed as $y = me$, where m denotes mean and the (continuous) distribution of income relative to the mean has density $f(e)$ with unit mean. Thus, aggregate demand is given by:

$$C(m) = \int c(em)\, f(e)de\ , \tag{5}$$

with $c(\cdot)$ as defined in (1). We also define the cumulative deviation, or fraction of total income accruing to individuals with a ratio to mean income of h or less:

$$F(h) = \int_0^h ef(e)de\ ,$$

with $f(e)$ as the associated density. We study the effect of a shift in mean income m on the aggregate demand function (5) and formulate the following proposition:

Proposition: *Suppose that income growth is positive and identical for all individuals in a group. Then, the slope of the aggregate meat-demand curve (5) is rising (falling) with mean per-capita income if and only if there is more (less) total income spent on meat at* $\underline{y}$ *than at* $\overline{y}$, *i.e. if and only if* $(b_2 - b_1)f(\underline{y}/m)\underline{y} - (b_2 - b_3)f(\overline{y}/m)\overline{y}$ *is positive (negative).*

Proof.
$$\frac{\partial C}{\partial m} = \int \frac{\partial c(em)}{\partial y} ef(e)de = b_1 \int_0^{\underline{e}} ef(e)de + b_2 \int_{\underline{e}}^{\overline{e}} ef(e)de + b_3 \int_{\overline{e}}^{\infty} ef(e)de$$
$$= b_1 F(\underline{y}/m) + b_2\left(F(\overline{y}/m) - F(\underline{y}/m)\right) + b_3\left(1 - F(\overline{y}/m)\right)$$

hence, since $\dfrac{\partial F(y/m)}{\partial m} = \dfrac{dF(e)}{de}\dfrac{e}{m} = -f(e)\dfrac{y}{m^2}$, it follows that

$$\frac{\partial^2 C}{\partial m^2} = \frac{b_1}{m^2}\left(-f(\underline{y}/m)\underline{y}\right) + \frac{b_2}{m^2}\left(f(\underline{y}/m)\underline{y} - f(\overline{y}/m)\overline{y}\right) + \frac{b_3}{m^2}\left(f(\overline{y}/m)\overline{y}\right)$$

[2] Deininger and Squire (1996) provide a database on income distribution for major countries.

$$= \frac{1}{m^2}\left((b_2 - b_1) f(\underline{y}/m)\underline{y} - (b_2 - b_3) f(\overline{y}/m)\overline{y}\right).$$

Regarding the interpretation of this form, since $y = $ ìå, it follows that $y f(y/m)$ is the total income corresponding to per-capita income y. Multiplication by $(b_2 - b_1)$ and $(b_2 - b_3)$ leads to the total additional expenditure on meat by the individuals crossing the regime boundaries. In other words, the slope increases as long as the difference between the weighted fraction of income spent at $\underline{y}$ and $\overline{y}$ is positive and thus, an increasing fraction of the income is spent on lifestyle 2. Hence the convexity depends on the shift in expenditure distribution, which is due to both population and income growth.

To demonstrate the empirical relevance of this proposition, Figure 3 shows the impact of future income growth on the distribution of per-capita income in two regions, South- and East Asia. The diagrams on the left of Figure 3 correspond to GDP growth rates as used for instance in FAO (2000) (see Table A-1). In the light of the current economic slowdown, these rates seem fairly high. For example, for the period 1997-2015 they imply annual growth in per-capita income of 4.1 percent in India, 6.7 percent in China or 5.2 percent in East Asia. Therefore, we also include two diagrams on the right that refer to a second scenario where per-capita growth is reduced by one-third. It appears that for both scenarios, mean income will shift from the lower income threshold (vertical line on the left) towards the upper threshold. For East Asia it even crosses by 2030. Based on these shifting income densities, we compute the (weighted) fraction of income spent at each level of per-capita income (Figure 4). This provides a graphical illustration of the principle set out in Proposition 1. As the weighted income fraction spent at the two thresholds $\underline{y}$ and $\overline{y}$ is indicated with vertical lines, we can simply read off from the diagram whether the corresponding difference is positive in terms of the Proposition, and thus, whether the aggregate meat demand curve is convex increasing for a particular year.

It appears that for 1997, this is indeed the case for both regions. In later years a difference emerges. Whereas for East Asia the curve already becomes concave increasing in 2000, for South Asia this only happens by 2020. IFPRI (2001) and FAO (2000) find lower growth rates, due to anticipated satiation effects but these projections disregard the lower threshold and hence the takeoff of consumption as well as the fact that large segments of the population have not yet reached satiation. These are the two aspects incorporated in our calculations.

Since China plays a key role in these calculations, let us elaborate on the reliability of our assumptions for this country. Several studies report substantial discrepancies between domestic consumption levels as implied by official Chinese statistics on livestock and meat output, and those reported by household surveys suggests, and come to the conclusion that official data on per-capita meat consumption are biased (Colby et al., 1998; Lu, 1998; Fuller et al., 2000) with underreporting in the early 1980s, because the statistics failed to capture the spectacular growth in production, while, in the 1990s the officials had an incentive to overstate production levels. Furthermore, consumption levels were increasingly obtained from household surveys that tend to neglect food consumed outside the home as well as consumption of migrant workers in urban areas, both of which have gained in importance during the 1990s. Nonetheless, in their overall

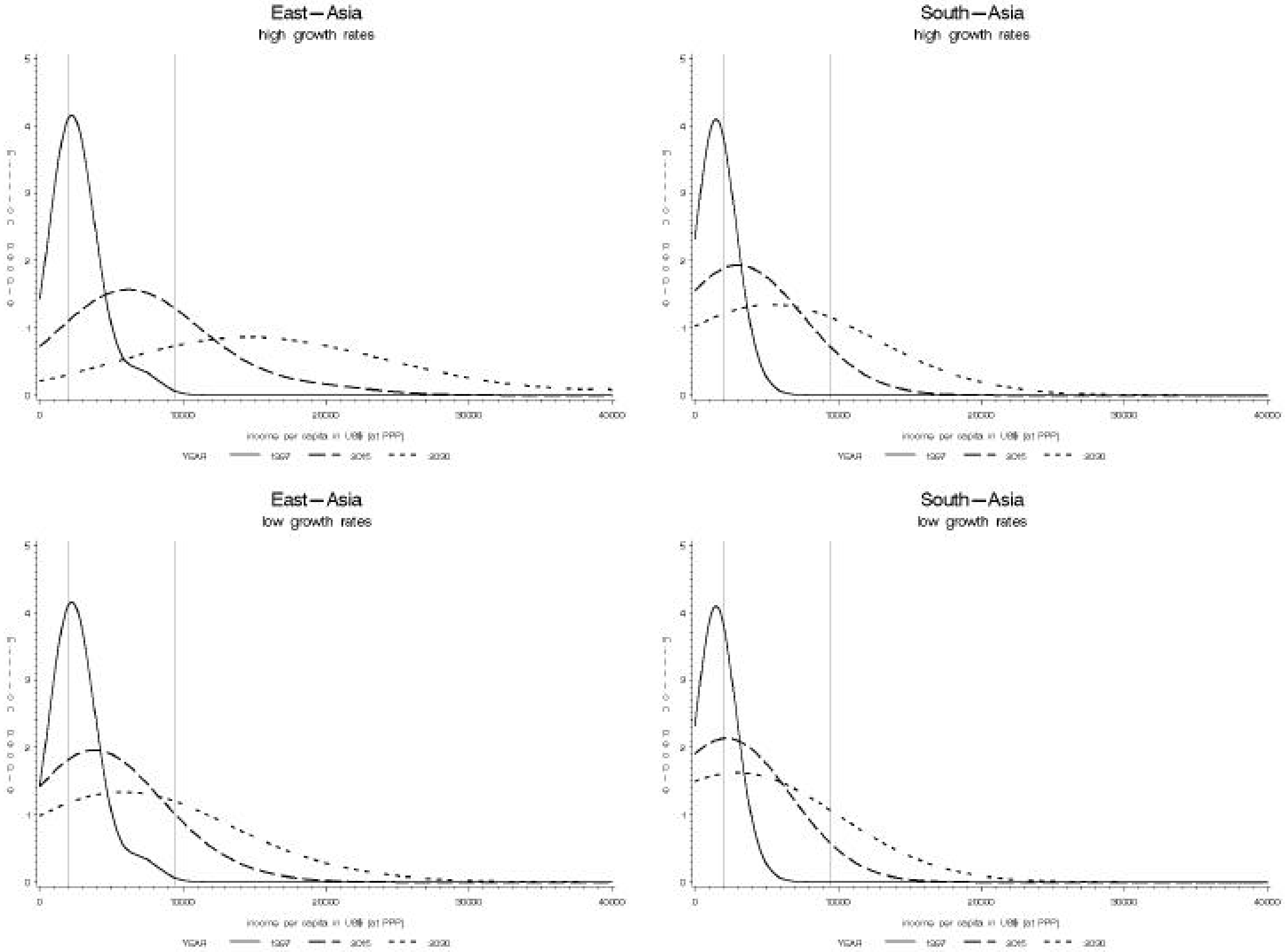

Figure 3. Effect of economic growth on income distribution

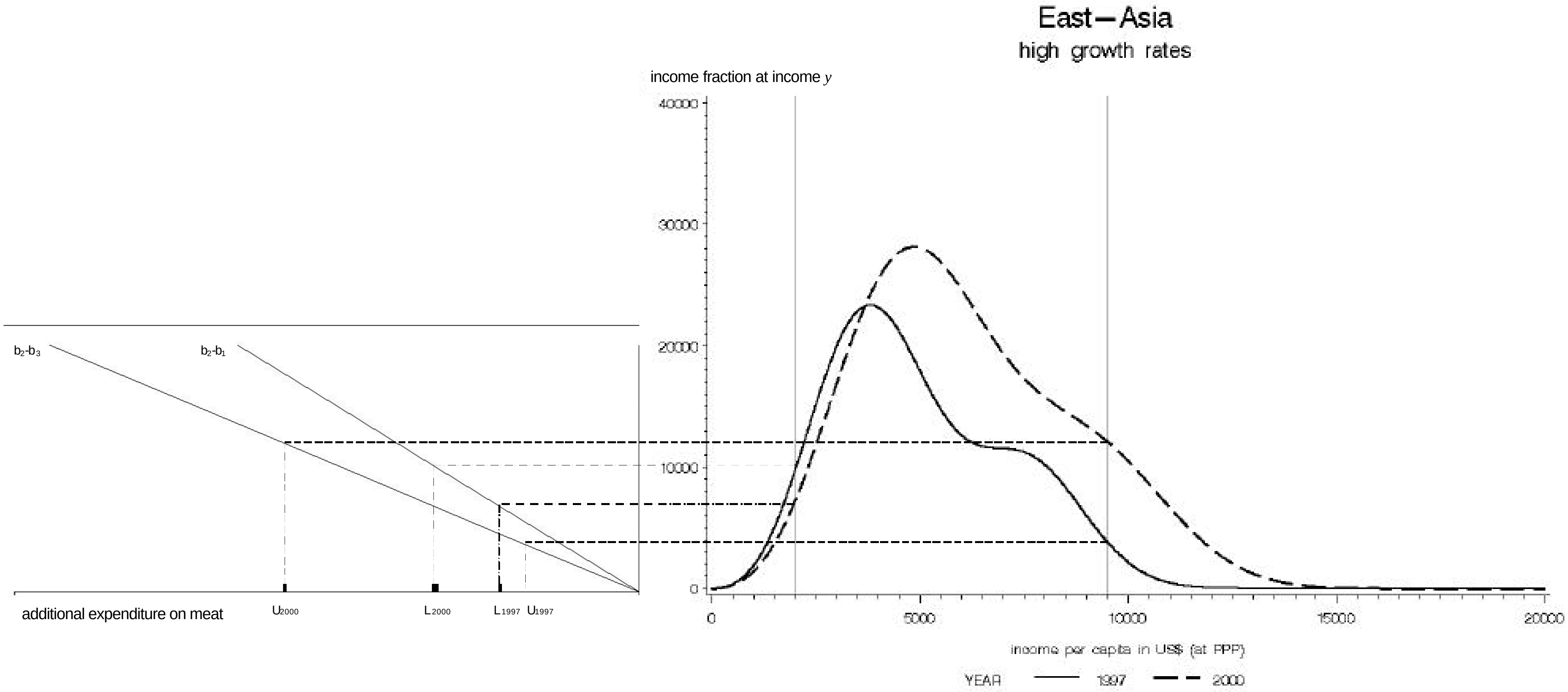

Figure 4a. Effect of economic growth on expenditure on meat (I)

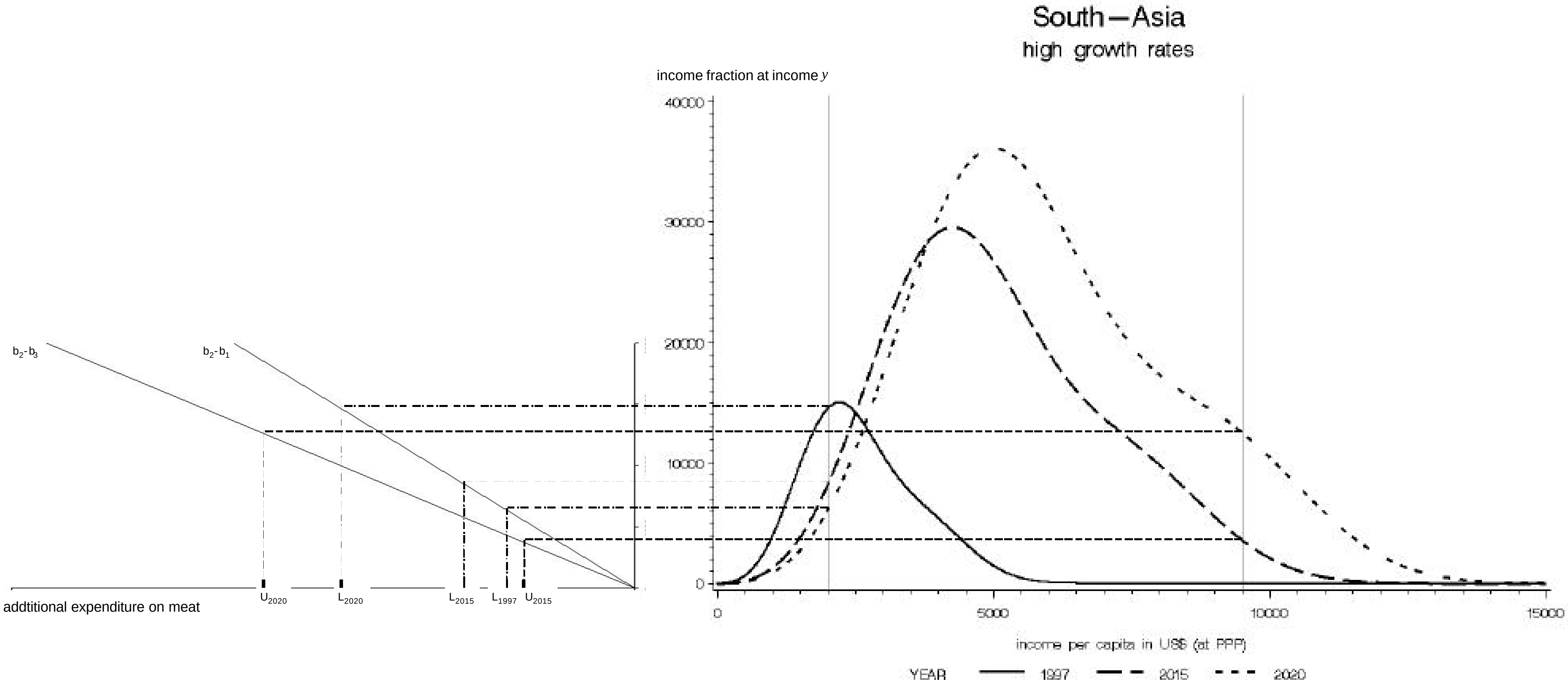

Figure 4b. Effect of economic growth on expenditure on meat (II)

conclusion, the three studies mentioned claim that nowadays official statistics tend to overstate consumption whereas they understated it in the early 1980s. Interestingly, our calculations based on cross country estimates confirms this: FAOSTAT (2002) data fall below our estimates in the early 1980s and increasingly exceed them after 1985 (Figure 5). Furthermore, we find our estimates for per-capita consumption of total meat in 1998 (29 kg/year) to lie fairly close to the adjusted estimates given by Fuller et al. (2000) of 28 kg/year. In addition, Lumpkin (1996), amongst others, argues that China is more likely to follow the meat consumption pattern of Taiwan and Hong Kong, with high per capita meat consumption (60 and 90 kg per capita annually, respectively), than that of Korea or Japan, where the share of meat in the diet is much lower as more fish is consumed (with per capita annual meat consumption being 46 and 44 kg, respectively).

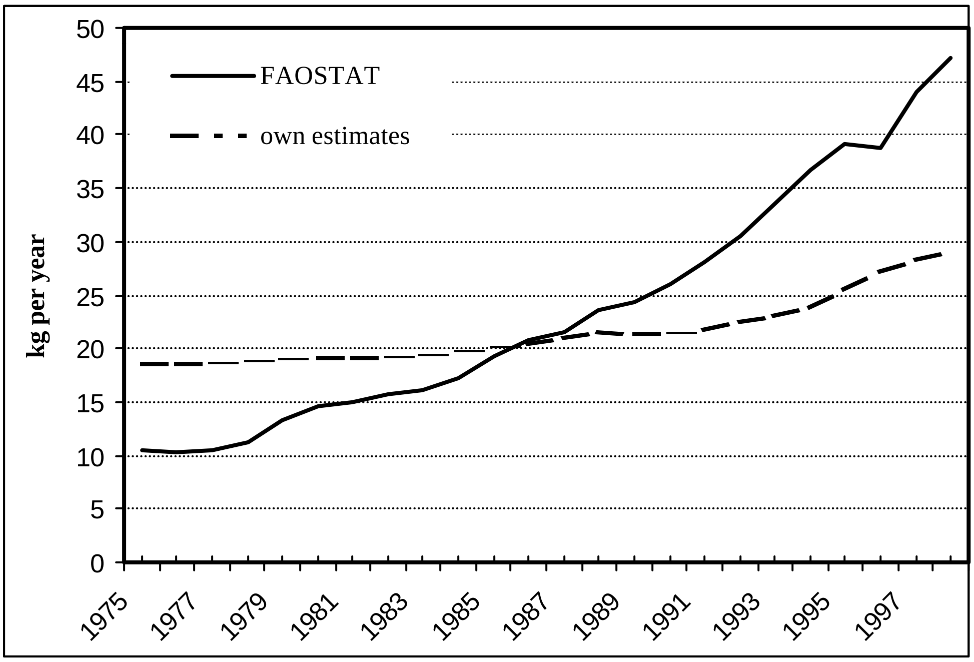

Figure 5. Per-capita meat consumption in China: FAOSTAT data vs. own estimates

Demand projections

Next, we use the estimated Engel curve to project meat demand based on per-capita income and to calculate from there the annual growth of aggregate meat demand and per-capita consumption of meat by region. To allow for country specific effects in addition to the four dummies that are already included in the estimation, we scale projected levels of per-capita consumption for each country[3] and year by a constant factor such that the projected value for 1997 coincides with the

[3] Except China, for the reason mentioned earlier.

value given in the data. We compare our findings with the projections of FAO (2000).[4] As shown in Table 2, we find that only for Sub-Saharan Africa, the region with the lowest anticipated income growth but the highest population growth, FAO (2000) projects higher annual growth rates than our projections based on the same rates of growth in per-capita income (*High Growth).* In all other regions our calculations project higher increases of aggregate demand, and the difference is especially pronounced for the two Asian regions where projected growth is highest. Even if we reduce initial growth rates by one third (*Low Growth*) we find that our estimations still tend to exceed the FAO projections for most regions such that even under lower levels of per-capita growth in income, global demand for meat still increases by higher rates.

Table 2. Annual growth rates of aggregate meat consumption (in percent)

	High growth rates		Low growth rates		FAO (2000)	
	1997-2015	2015-2030	1997-2015	2015-2030	95/97-2015	2030
Sub-Saharan Africa	3.0	2.9	2.8	2.5	3.4	3.1
Near East/North Africa	4.1	3.2	3.4	2.8	3.4	2.6
Latin America and Caribbean	2.6	1.8	2.3	1.6	2.3	1.8
South Asia	5.8	3.9	4.4	3.7	3.6	3.5
East Asia	4.9	2.6	3.7	2.6	2.8	1.5
Transition Countries	1.3	1.2	1.0	0.9	0.7	0.4
Industrial Countries	1.4	1.2	0.9	0.8	1.1	0.7
World	3.0	2.2	2.3	1.9	1.9	1.4

Source: FAO (2000) and own projections

Differences are similar when we compare per-capita meat demands (Table 3). Again we find that our estimates exceed those of the FAO for most years under both scenarios, especially for the Asian regions, the Near East and North Africa. For the *High Growth* scenario, we find world-level differences in annual per-capita demand of 4.9 kilogram in 2015 and 10.6 kilogram in 2030. This corresponds to additional consumption of about 34.7 million tons in 2015 and 85.8 million tons in 2030.[5] Moreover, although global per-capita demand under *Low Growth* rates is similar to the FAO estimate for 2015, it exceeds it by 2.5 kilogram in 2030, which amounts to a difference of 20.6 million tons.

[4] In the projections, dummy variables for India only apply for regimes one and two. Satiation starts at 34kg per capita per year with USD 5000.

[5] World population is assumed to total 7.1 billion in 2015 and 8.1 billion in 2030.

Table 3. Per-capita consumption of meat (in kg/year)

	Base year	High growth rates		Low growth rates		FAO (2000)		
	1997	2015	2030	2015	2030	1995-97	2015	2030
Sub-Saharan Africa	11.5	12.5	14.3	12.0	12.9	9.7	11.6	13.6
Near-East/North-Africa	22.9	32.9	43.3	29.0	35.8	20.0	26.6	32.0
Latin America and Caribbean	50.9	62.8	70.9	59.3	65.7	48.5	57.8	66.0
South-Asia	5.8	12.2	18.7	9.7	14.5	5.5	8.2	11.8
East-Asia	27.2	54.7	74.7	44.6	60.5	33.3	47.2	55.0
Transition Countries	82.3	98.3	115.1	93.0	103.8	86.5	93.0	97.0
Industrial Countries	46.1	58.6	71.0	54.2	62.3	49.4	61.0	69.0
World	32.6	44.9	54.6	39.7	46.5	34.7	40.0	44.0

Source: FAO (2000) and own projections.

Our projected per-capita demand for India of 11.8kg per year (8.9kg) in 2015 and 17.9kg (13.8kg) in 2030 for the *High Growth* (*Low Growth*) scenario differs substantially from what is implied for India by FAO (2000) or explicitly projected by IFPRI (2001) in their baseline scenario (7.4kg). This needs further comment since results for the entire South-Asian region are largely driven by projections for India that accounts for more than 70 percent of the total population. Traditionally meat consumption in India has been low even in relation to per-capita income, for well known religious and cultural reasons. Starting from such a low level and using income elasticities similar or even below those of other Asian countries, these studies do not find a substantial increase of per-capita demand. Evidence for such low elasticities can for example be found in Mohanty et al. (1998) who estimate Engel curves for food demand based on official consumer-expenditure data. However, these data ignore out-of-home consumption of meat, a phenomenon of increasing importance, especially in urban areas. Furthermore, there is evidence that Indian consumers tend to drift away from vegetarianism towards protein from animal origin as they become richer. Bhalla et al. (1999) for instance find that income elasticities for meat and egg in rural areas have been increasing since the early 1970s, and that an increasing share of households in both, rural and urban areas reports to eat meat.[6] Abdulai et al. (1999, p.324) find that increasing urbanization is likely to raise the consumption of this commodity group. Based on this evidence, IFPRI (2001) has considered an alternative scenario with significantly higher income elasticities. Under this scenario, the projected level of per-capita demand for meat in 2020 (18kg per capita) even exceeds our estimate for that year (13.5kg).[7] Nonetheless, it must be acknowledged that, particularly because of the religious aspects, these changes in demand patterns remain highly uncertain in India.

[6] Following Bhalla et al. (1999, p. 4), while only 43.7 and 31.5 percent of urban and rural households reported to consume meat in 1987/88, both shares increased to more than 50 percent in 1993-94.
[7] The difference is partly due to a higher rate of income growth (5.5 percent in IFPRI (2001) versus 4.1 percent in our study).

To indicate more sharply that the rise in demand is due to per-capita income rather than to population growth, we run an alternative scenario with zero per-capita growth. Table 4 compares the outcome with *High Growth*. It appears that for Asia, growth in per-capita income accounts for 70 (South Asia) and 80 percent (East Asia), respectively, of total increases in aggregate meat demand, while for Sub-Saharan Africa between 1997 and 2015, only about 20 percent of the growth in aggregate meat demand is attributable to income growth and 30 percent in the period 2015-2030.

Table 4 also reports on another variant that accounts for changes in income distribution within countries. For this we use the relation estimated by Dollar and Kraay (2000), according to which the growth rate of the poorest twenty percent of the population is about seventeen per cent higher than among the remainder of the population. Applying this relationship, more people enter the mid-interval with a high marginal propensity to consume, and this raises the slope of the aggregate Engel curve even further. Yet, since the average growth rate per country is kept unchanged, this is largely compensated by a drop in the growth rate of the four upper quintiles below the given average. Overall, Table 4 suggests that both effects tend to cancel out.

Table 4 . Annual growth rates of aggregate meat consumption for alternative scenarios (in percent)

	High Growth Rates		Zero Growth		Dollar/Kraay	
	1997-2015	2015-2030	1997-2015	2015-2030	1997-2015	2015-2030
Sub-Saharan Africa	3.0	2.9	2.5	1.9	3.0	2.9
Near East/North Africa	4.1	3.2	1.8	1.2	4.1	3.2
South Asia	5.8	3.9	1.8	1.1	5.8	3.9
East Asia	4.9	2.6	0.9	0.5	4.9	2.7

Source: FAO (2000) and own projections

To sum up, if we apply a kinked demand curve for meat in conjunction with information on the income distribution within countries, and assume that all individual incomes and population level grow at a common rate in every country, or differ in accordance with the Dollar-Kraay relationship, we find an acceleration of the growth in meat demand during the period 2000-2030, particularly in the first half. We conclude that current international projections might significantly underestimate world meat demand in the coming fifteen years.

Section 3
Implications for feed demand

In this section, we study the impact of the surge in meat consumption on the demand for animal feed. For world food markets at large this is the key issue, since in the end it is the feasibility of supplying livestock with feed, and to a lesser extent of absorbing its manure, that will determine whether the growth in livestock production can be realized and how much pressure this will exercise on food markets.

The major feed components of commercial feed are cereals, root crops, and oilseeds. Following the approach by the FAO (2000) and IFPRI (1999; 2001) studies, we concentrate on the consequences for cereal markets, and express the demand for root crops and oilseeds in cereal equivalents, using their yield ratios[8]. We also follow these studies in assuming that developing countries will have to produce domestically most of the meat they consume and determine on the basis of the projected meat demand the resulting need for, possibly imported, cereal feed. We depart from these studies in that we treat the cereal/meat ratios as being depended on the level of meat demand. Moreover, rather than keeping these ratios fixed at levels that are much higher for developed than for developing countries, we will argue that developing countries - just like developed countries - have to invoke more feed intensive technologies as meat demand outpaces the supply of grazing area and of crop residuals and household wastes.

Table 5. Feed intensity as cereal-meat ratio [kg/kg]

FAO AT2015/30				
Year	84/’86	95/’97	2015	2030
Developing countries	2.38	2.26	2.34	2.35
Industrial countries	4.66	3.91	3.86	3.85
IFPRI IMPACT model				
Year	1993	1997	2020	
Developing countries	2.20	2.12	2.03	
Developed countries	4.42	4.35	4.31	

Source: Adapted from FAO (2000) and IFPRI (1999; 2001)

Specially, Table 5 indicates that, according to the two studies mentioned, the feed ratios in industrial countries reflect declining improvements in feeding efficiency, e.g. due to better management, better genetic breeding material and better feeding practices. Indeed, intensive livestock production in Western Europe has realized this kind of improvement consistently over the past. Yet, these ratios stay much higher than in the rest of the world. In contrast, feeding systems in the developing countries rely to a large extent on crop residues and household waste,

[8] Henceforth, all references to cereal feed relate to cereals, root crops, and oilseeds, expressed in cereal equivalents.

with some supplementary feed from cereals and cereal substitutes. This is reflected in the lower average feed requirements that hardly shift over time. According to FAO and IFPRI, this constancy is the outcome of two trends that cancel out: a shift towards more feed intensive production technologies, and increases in feeding efficiency. However, as we will argue below, assuming that developing countries will be able to let their meat production grow with lower feed/meat ratios that the industrial countries amounts to confusing average and marginal input requirements. Instead, to satisfy the rapidly expanding demand for meat, developing countries will need a relatively intensive livestock industry, and a higher share of cereals in the feed used. This means that in the medium term, their cereal/meat ratios will tend to rise rather than fall.

To substantiate this assertion, we follow as much as possible the regional aggregation used in section 2, and distinguish six regions,[9] indexed i. Furthermore, we consider five animal types[10], indexed k. To reflect possible shifts to more intensive livestock production technologies, we follow Seré et al. (1995) and De Haan et al. (1997) in distinguishing three main systems for livestock production, namely grassland based systems, mixed farming systems and intensive livestock farming[11], and use the index j to refer to these systems. This distinction is needed to account for the limited availability of grazing areas. Finally, since we are concentrating on cereals, we split total feed use as reported in Seré et al. (1995) and De Haan et al. (1997) into cereal equivalents (i.e. cereals, roots, and oilcrops), and residuals (feed elements such as processed fruits, processed vegetables, animal offal, and cereal brans, which can be classified as by-products of food production, and household and crop wastes). This splitting is critical, as the availability of residuals depends on household consumption and crop production.

We define meat production at the level of the animal as the carcass weight of the animal at the time of slaughtering, denoted by $w_{i,k,j}$, expressed in mt/head. The number of animals in a region that can be slaughtered without decreasing the potential for the future (the offtake expressed in animal heads) at most equals the net addition[12] to the herd in heads, and the offtake rate $r_{i,k,j}$ therefore equals the net addition divided by the herd size. Denoting the number of animals in a region by $n_{i,k,j}$, measured in 1000 heads, total meat production $Q_{i,k,j}$, measured in 1000 mt, follows as:

$$Q_{i,k,j} = r_{i,k,j} \cdot n_{i,k,j} \cdot w_{i,k,j}, \tag{6}$$

and the feed/meat ratio $f_{i,k,j}$ by animal type and production system is given as:

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[9] These are: Sub-Saharan Africa, Near East/North Africa, Latin America and the Caribbean, Asia, Industrial Countries, and Transition countries.
[10] Cattle, buffalo, small ruminants (sheep and goats), pigs, and poultry.
[11] For a description of these systems and their different manifestations under various climatic conditions and for different regions, see e.g. Seré et al. (1995), De Haan et al. (1997), FAO (2001a and 2001b).
[12] Since we do not have separate data on mortality rate, birth rate, and losses through other causes, we only use net increase here.

$$f_{i,k,j} = D_{i,k,j} / Q_{i,k,j}, \tag{7}$$

where $D_{i,k,j}$ is the total regional feed use (cereals and residues) by animal type and production system, expressed in 1000 mt. To account for the possibility of different technologies, we introduce the parameter $s_{i,k,j}$, the share of each production system in the regional production of meat of type k. Finally, since we concentrate on the consequences for cereal feed, we introduce the factor $c_{i,k,j}$, the share of cereals in total feed use, to arrive at the feed demand for cereals g_i per kg of meat as:

$$g_i = \sum_k \sum_j s_{i,k,j} c_{i,k,j} f_{i,k,j} . \tag{8}$$

Table 5 shows that in both FAO (2000) and IFPRI (2001) cereal/meat ratios are essentially kept constant.[13] This amounts to assuming that the complement of the cereal part of feed, the residuals, grows at the same pace as cereal feeds (i.e. a constant $c_{i,k,j}$ is assumed), and the same holds for the availability of grazing area. In short, FAO and IFPRI assume that no major changes occur in the feeding technology mix used in developing countries as meat demand increases.

In the following, we show that based on relationship (8), calibrated using data presented in Seré et al. (1995) and De Haan et al. (1997), and assuming constant $c_{i,k,j}$, the increase in meat demand as projected for 2015 and 2030 requires an unrealistically large expansion of residual feed. For this, we use the high meat demand variant, for each region and type of meat.

Since FAO and IFPRI claim that technological innovation counterbalances the increase in feed demand, we also include possibilities for increases in offtake rates, carcass weight, and efficiency improvements in feeding. Improvements in animal health affect both the offtake rate $r_{i,k,j}$ and the carcass weight $w_{i,k,j}$. Especially in Africa, diseases have a large impact: the most important effect of trypanosomiasis seems to be a decrease in the birth rates and an increase in the mortality rates of young animals. For example, Swallow (2000) finds reductions in calving rates between 1-12% in tolerant breeds of cattle and 11-20% for breeds that are relatively susceptible to the disease, while calf mortality rates increase by 0-10% and 10-20%, respectively. For herds of goats and sheep, similar results are found. Further improvements in the feed/meat ratio can be achieved by introducing genetically better breeds, by using higher quality feed, and by improving management of the production system. Whereas technological improvements will lead to a lower feed/meat ratio, there is also a trend in consumer preferences that may run counter to this. Rosengrant et al. (2001), and IFPRI (1999), for example, both expect a shift in the shares of the different types of meat in total meat consumption, away from ruminants and pork, and towards poultry. Haley (2001) provides empirical evidence that such a shift to a large extent already has

[13] Yet, the IFPRI study implements a sensitivity scenario is run with gradually lower feed efficiencies. It shows that cereal use increases substantially and makes substitution to other feed intakes cost-effective (IFPRI, 1999, pp. 29-30).

taken place in the US, and therefore, there is all the more reason to expect such a consumption pattern to emerge in the developing countries as well.

Scenario formulation for feed demand: 2015 and 2030

To substantiate our claim that the FAO projections underestimate the demand for cereals as feed, we formulate three scenarios. The first, the Constant Cereal Residues Ratio (CCRR) scenario, follows FAO assumptions in assuming that residual feed and grazing areas will grow at the same pace as cereal feed demand. The second, the Residuals on Trend (RT) scenario, restricts the growth of residual feed to be at most equal to the rate of crop growth, an assumption made by, amongst others, CAST (1999). The third, the Residuals and Grass on Trend (RGT) scenario adds to the RT scenario that also the availability of grazing areas follows a growth path independent of meat demand but determined by the regional possibilities for expansion.

Within each of these three scenarios, we distinguish an optimistic and a pessimistic view on future development. In the optimistic view, there are increases in carcass weights, offtake rates and improvements in feeding efficiency, and no shift in consumer preferences towards poultry. To reflect possible improvements in health, we use the historical rate of growth of carcass weights and offtake rates, in the period 1961-2000, as reported in FAOSTAT (2002), but restrict the maximal levels for the regions to be at most 150% of the world-wide maximum as reported for 2000. With respect to improvements in feeding efficiency, we use the expected decrease in feed/meat ratios as reported by IFPRI (1999; 2001), since IFPRI (1999; 2001) and FAO (2000) only report on changes in the ratio, and not on changes in the elements of the ratio in addition to the projections on carcass weights and offtake rates mentioned above. In the pessimistic view, there are no technological advances and a shift away from red meat and towards poultry in included in the projections, following the implicit rates of growth of the share of poultry assumed in IFPRI (1999). Table 6 summarizes the characteristics of the scenarios, appendix tables A.2-A.4 present associated parameter values.

Table 6. Summary of scenario characteristics

	CCRR optimistic	CCRR pessimistic	RT optimistic	RT pessimistic	RTG optimistic	RTG pessimistic
Constant cereal/residue ratio	*	*				
Residual growth independent			*	*	*	*
Grazing area independent					*	*
Carcass weight increases	*		*		*	
Offtake rate increases	*		*		*	
Increases in feeding efficiency	*		*		*	
Shift towards poultry		*		*		*

Legend on scenarios
CCRR = constant cereal residues ratio
RT = residuals on trend
RTG = residuals and grass on trend

Scenario outcomes for feed demand: 2015 and 2030

For the CCRR scenario, Figure 6 shows the annual growth rates of cereals (and thus of residuals) for the period 2000-2015 and 2000-2030, for the world as a whole and for Asia and Africa separately, for a growth path that is halfway between the optimistic and the pessimistic projection. In these regions, high growth in residual feed intakes are necessary. Typically, these are regions were pressures on availability of these feeds are high already, and in Asia, the ongoing urbanization leaves little scope for expanding the supply of feeds from household wastes. In fact, USDA (2000) reports a major shift in Chinese intensive pig production from small backyard farms to specialized household production and commercial production, which implies an increase in the share of cereals in total feed from 43.7% to 67%.[14] Furthermore, the growth in these sources of feed is typically independent from the growth of meat demand (e.g. CAST, 1999, uses the rate of growth of crop production as indicative of the growth in residuals, although this might even be optimistic since high yielding crop varieties produce less residuals than traditional ones). As can be seen in the figure, projected annual crop growth rates are much lower than the required growth in residuals.

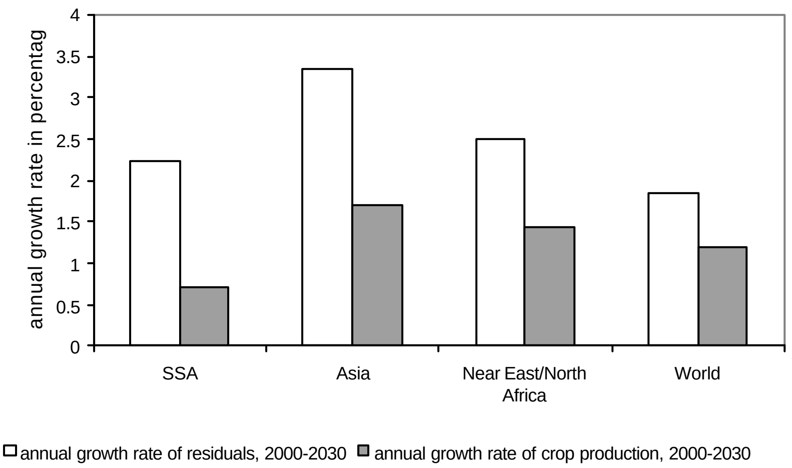

Figure 6. Annual growth rates for residual feed and projected crop growth rates

With respect to the assumed growth in the use of grazing areas (which is also equal to the growth in cereal feed demand), there are two arguments against such an expansion. First, most of the consumers who become richer and increase their demand for meat live in the urban areas of developing countries. Since it usually is more costly and difficult to transport live animals or (refrigerated) meat than animal feed, meat production tends to be located relatively close to consumers, that is in and around densely populated areas, in urban and peri-urban farms that

[14] In the period 1985-1996, the share of backyard farms in total production fell from 94.6% to 80.7%, while that of commercial farms rose from 2.5% to 4.7% of total production. The remaining production was carried out by specialized households that also use less residual feed than backyard farms, with cereals as 56.7% of total feed (USDA, 2000).

specialize on poultry, eggs, pork, dairy, and vegetables. Because of the high risk of contagious diseases for both humans and animals, and the high cost of urban land, urban farming is declining while peri-urban is expanding rapidly (FAO, 2001a).

Secondly, Asia and Africa are also typically regions where the scope for expansion of grazing land is limited. In West- and Central Africa, much of potentially suited land is not used for livestock keeping because of diseases (mainly trypanosomiasis/tsetse, FAO, 2002; Swallow, 2000, FAO, 2000b), or because necessary improvements of the land to increase grass yields are too costly (Alexandratos, 1995), while land that is very suited for livestock production is already used with high intensities (in Africa, the highest livestock densities are found in the highland regions of Ethiopia, East and southern Africa, FAO, 2001c). In Asia, increasing urbanization and the use of land for crop production limits the possibilities for extensive livestock production. (e.g. Steinfeld, 1998). Only in the lowlands of South America seems to remain room for a further expansion of grassland based livestock farming (Dixon et al., 2001, chapter 7).

Against this background, we conclude that in Asia and Africa the cereal/meat ratios will have to rise, as the feeding technology gradually shifts to more cereal-intensive feeding, and away from low-feed grazing systems and mixed farming systems and towards intensive livestock farming systems.

To illustrate the implications of restrictions on the availability of residual feed and grazing area, we now turn to the RT and GRT scenarios. In Figure 7, the world demand for cereal feed is plotted for each of the three scenarios, and using the pessimistic and optimistic views on future developments to define, for each scenario, the range of possible outcomes. For example, for the CCRR scenario, feed demand in 2030 ranges from 1135 to about 1500 million mt.

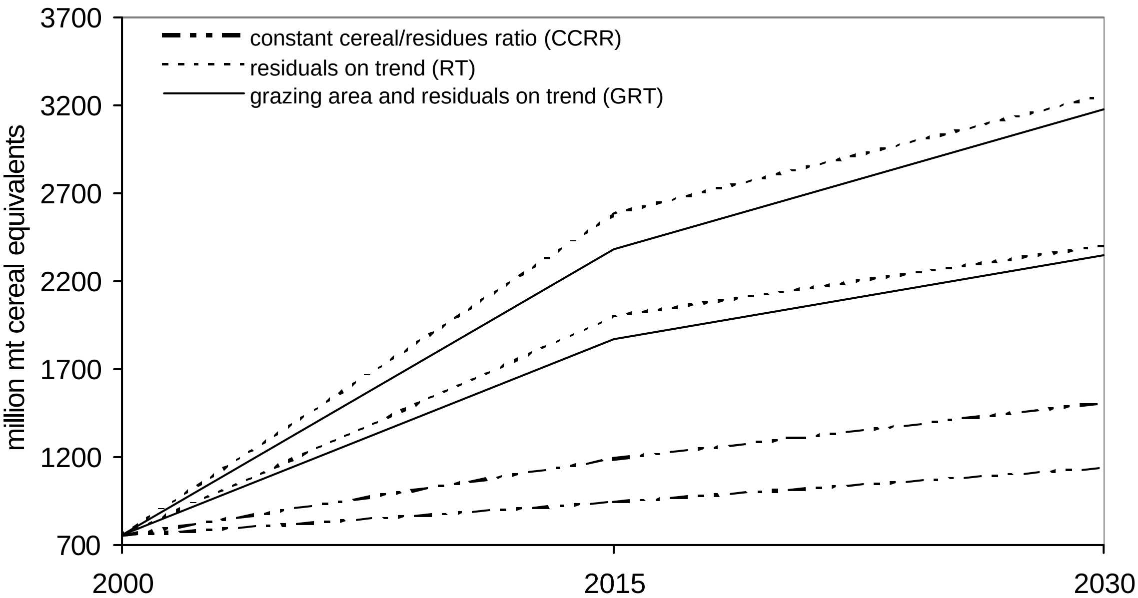

Figure 7. World demand for cereal feed, three scenarios

The most striking observation in Figure 7 is that there is a large gap between the CCRR scenario on the one hand, and the RT and GRT scenarios on the other. In fact, even under the optimistic view on technological advances, the projected cereal demand in the RT and GRT cases lies more than 50% higher than the most pessimistic outcome under CCRR. A closer look at the individual scenarios shows that under CCRR, predicted cereal demand lies between 1135 and 1507 million tons in 2030, where the optimistic prediction lies only slightly above the prediction of about 1100 million tons in FAO (2000). Under RT, (the dotted lines in the upper part of Figure 7) predicted cereal demand in 2030 ranges between 2400 and 3257 million mt. Finally, under GRT (the solid lines in Figure 7) there is some room for further use of grazing areas, especially in Latin America and the transition countries, but in 2030 it seems that the possibilities for expansion are exhausted, as is indicated by the fact that this scenario almost crosses the second one in 2030.

In sum, our calculations suggest that expected increases in meat demand will put considerable pressure on the cereal markets, as livestock feeding practices have to shift to regimes with higher intensity, due to the limited growth potential of residual intakes. The availability of grazing areas in Latin America and the transition countries can dampen this effect somewhat on the medium term, but in the longer run, also there, boundaries on the expansion of grazing-based production systems will be met.

Two qualifications are in order. One is that our projections do not include possible price effects, and one could argue that relatively modest increases in meat prices could prevent meat demand from rising to our projected high levels. Therefore, we use price elasticities for meat demand as reported in IFPRI (1999) to calculated the price changes that are necessary to reduce meat demand enough to cause the projected feed demand under the GRT scenario in Figure 7 to remain at the level projected by FAO (CCRR); we compare optimistic views in both cases. From this, it follows that in 2015, meat prices should be on average 92% higher than in the CCRR scenario outcomes for 2015, with required prices for Asia being even 117% higher. For 2030, similar results are found: the regional average of meat prices should lie 96% above the 2030 CCRR scenario outcomes, with Asia again needing the largest increase in meat prices of 119% above CCRR prices. Therefore, only strong price increases in meat may fully reduce the pressure on cereal markets that follows from our projections RT and GRT.

The second qualification is that we might be overly optimistic about future income growth in Asia. Even though growth persists in China, with reported growth rates of GDP in 2001 being 7.8% (National Bureau of Statistics of China, 2002), overall expansion in Asia is 4.2% (World Bank). Therefore, we have also calculated the maximum allowable income growth that would lead to the meat demand consistent with the feed demand of CCRR in Figure 7. It appears that for the period 2000-2015, meat demand in Asia could then grow only at a rate of 0.4% annually, which implies negative per capita income growth, since population growth is projected to be 1.8% annually. For 2000-2030, the annual growth rate of meat demand could be at most 1.2%, which implies almost zero per capita growth as population in projected to rise at a rate of

1.1% annually. Therefore, even under very modest growth, the CCRR scenario would seem unattainable.

Section 4
Conclusion

This paper argues that the most important question in the future in relation to food issues is not whether we can feed the population, but whether we can feed the animals. The two main findings of the paper that support this claim are first, that per-capita meat demand will rise faster than would be predicted on the basis of fixed income elasticities, because in most developing countries the poorer half of the population has just entered or still is to access the income bracket where a significant fraction of income growth is spent on meat. Secondly, with respect to meat production, we claim that the often made implicit assumption of an unchanged composition of animal production systems cannot be sustained, and this implies that feed/meat ratios in developing countries will increase in the next decades, rather than fall as is assumed by FAO. Three projections on the possibilities for meat production in the next decades were presented, each with lower and upper bounds defined by assumptions on technological changes in feeding efficiency, carcass weights, and offtake rates: one which follows closely the FAO assumptions; one where the availability of residuals is bounded to be on trend, and, finally, one in which in addition to residuals, also available grazing area is bounded be on trend. The outcomes showed that, in the first scenario, the demand for feed increases at a modest rate, but this modesty is accompanied by a need for extremely high growth rates of grazing lands, and residues, and it is highly unlikely that such unprecedented growth can actually be realized. In the second scenario, feed demand, even under optimistic assumptions on technology, is 69% higher than in the first scenario in 2015, and 59% higher in 2030, but by design, the growth rate of residuals are on trend. Finally, under the third projection, also grazing lands are on trend, and it is assumed that all grazing areas are used. Here, cereal feed demand exceeds that of the FAO predictions by 57% and 56%, for 2015 and 2030, respectively, which implies that in the medium run, there is some room to use more grazing area, especially in Latin America. However, in 2030, these resources are also almost exhausted.

The claim that there will be much more pressure on cereal markets than commonly assumed is corroborated further if we take two other trends into consideration. First, it appears from FAO's Food Balance Sheets (FAOSTAT, 2002) that the percentage of industrial and household waste exhibits a pronounced increase as the economy shifts towards more intensive food-processing technologies. For example, consumers in the economies of Western Europe appear to have a food availability in the range of 3600-3700 kcal per capita per day. This lies far above actual per-capita food intake, and this situation will remain basically unaltered even when some of the slack in the world food system is eliminated (Smil, 2000). When developing countries also experience this transition, the pressure on primary production will intensify, especially in a transition period when the food processing industry is not yet capable of using large quantities of industrial and household waste for the production of feed. Second, the rise in meat demand is only one element of this process. In parallel with meat, the demand for fish will rise and in many countries consumers prefer fish to meat. Rather than easing the pressure on feed demand this will only exacerbate it. In general, the same mechanism is at work here, with a shift from marine fisheries (that requires no feed) to (intensive) aquaculture that requires feeding. Brown et al. (2001), for instance, calculate annual growth rates for aquaculture of 11.4 percent between 1990 and 2000, more than four times as high as growth rates for other important animal-protein sources such as pork (2.5 percent), beef (0.5 percent) or oceanic fish catch (0.1 percent). Thus, the strong demand for fish will increasingly shift resources to modern - feed intensive - aquaculture and thus add to the pressure on feed markets.

If we turn to factors influencing the production of feed, in comparison with other factors that are generally expected to affect the future world food situation, such as Genetically Modified Organisms (GMOs) and climate change, the quantitative importance of the meat issue is impressive. Regarding GMOs controversy persists, and only few studies point towards potential yield improvements (e.g. Klotz-Ingram et al., 1999). The major anticipated effects are to save on chemical inputs, better nutritional quality of GMO-food, but worldwide the effect on supply volumes appears to be limited. The effects of climate change on agricultural markets stretch out over longer period and very different across regions. Fischer et al. (2001) calculate total losses of potential cereal production in 2080 of 105 million tons. Even if this change was realized in 2030 already, it would still be modest compared to the projected increased demand of almost 1900 million tons world-wide that follows from intensive production of meat demanded.

Finally, we emphasize that the present calculations only serve as initial explorations. Within the framework presented, more data could be accommodated to improve the estimation and calibration procedures for meat-demand and feed-requirement functions, respectively. We note in this context that these computations do not intend to substitute for projections by more elaborate models with endogenous prices, although we presented some intuition on required price changes. However, these models can only reflect the available knowledge with respect to supply and demand and in our view filling the data gaps is the first priority. This is a demanding task that calls for an important concerted effort. But the issue deserves it.

Appendix

Table A.1 Projected growth rates for GDP and population

	GDP per capita				Population	
	High Growth		Low Growth			
	1997-2015	2015-2030	1997-2015	2015-2030	1997-2015	2015-2030
Sub-Saharan Africa	1.5	2.1	0.8	1.1	2.5	2.0
Near East/North Africa	1.8	2.7	0.9	1.3	2.0	1.4
Latin America and Caribbean	2.4	3.2	1.2	1.6	1.4	0.9
South Asia	3.8	4.0	1.9	2.0	1.6	1.0
East Asia	5.2	5.8	2.6	2.9	0.9	0.5
Transition Countries	2.4	2.6	1.2	1.3	0.4	0.1
Industrial Countries	3.3	4.1	1.6	2.0	0.0	-0.1
World	2.1	2.7	1.0	1.4	1.2	0.8

Source: FAO (2000) and own projections.

Table A.2 Projected annual growth rates for carcass weights

	Beef/veal	Buffalo	Small ruminants	Pigs	poultry
Sub-Saharan Africa	-0.16	0.00	0.06	0.14	0.08
Asia	1.10	0.01	0.37	0.33	1.52
Latin America and Caribbean	0.18	0.00	-0.16	0.46	0.35
Near East/North Africa	1.10	0.16	0.42	0.27	0.73
Industrial Countries	1.12	2.31	0.01	1.03	0.40
Transition Countries	1.33	0.77	-0.14	-0.41	1.36

Source: FAOSTAT (2002) historical trends for 1961-2000. Note that carcass weights are bounded to stay within 150% of maximum and 90% of minimum in 2000.

Table A.3 Projected annual growth rates for offtake rates

	Beef/veal	Buffalo	Small ruminants	Pigs	Poultry
Sub-Saharan Africa	0.11	0	0.26	-0.01	1.51
Asia	3.29	1.20	3.13	2.71	2.05
Latin America and Caribbean	0.28	0	0.94	1.03	3.34
Near East/North Africa	1.63	1.13	0.75	2.03	1.18
Industrial Countries	0.00	-4.95	0.60	0.58	1.66
Transition Countries	-0.03	2.10	1.17	0.77	3.31

Source: FAOSTAT (2002) historical trends for 1961-2000. Note that offtake rates are bounded to stay within 150% of maximum and 90% of minimum in 2000.

Table A.4. Projected growth of residuals and grazing area

	Residuals	Grazing area
Sub-Saharan Africa	0.72	0
Asia	1.71	-0.19
Latin America and Caribbean	0.37	0.15
Near East/North Africa	1.43	0
Industrial Countries	1.65	-0.18
Transition Countries	0.86	-0.05

Source: FAOSTAT (2002) historical trends for 1995-2000.

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The Centre for World Food Studies (Dutch acronym SOW-VU) is a research institute related to the Department of Economics and Econometrics of the Vrije Universiteit Amsterdam. It was established in 1977 and engages in quantitative analyses to support national and international policy formulation in the areas of food, agriculture and development cooperation.

SOW-VU's research is directed towards the theoretical and empirical assessment of the mechanisms which determine food production, food consumption and nutritional status. Its main activities concern the design and application of regional and national models which put special emphasis on the food and agricultural sector. An analysis of the behaviour and options of socio-economic groups, including their response to price and investment policies and to externally induced changes, can contribute to the evaluation of alternative development strategies.

SOW-VU emphasizes the need to collaborate with local researchers and policy makers and to increase their planning capacity.

SOW-VU's research record consists of a series of staff working papers (for mainly internal use), research memoranda (refereed) and research reports (refereed, prepared through team work).

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