ELSEVIER

Agricultural Economics 15 (1996) 1–16

AGRICULTURAL ECONOMICS

China's projected cereals deficits in a world context [1]

Nikos Alexandratos [2]

Food and Agriculture Organization of the United Nations, Viale delle Terme di Caracalla, 00100 Rome, Italy

Accepted 10 May 1996

Abstract

Lester Brown's recent writings about trends in China's food consumption, production and rapidly rising import requirements and his predictions that the world is running out of potential to increase production of cereals received wide publicity in the press. They increased awareness of the problem among the public, which was stimulated by recent declines in world cereals production per capita, falling stocks and sharp rises in world market prices. This paper is an attempt on my part to extract a coherent picture of what Brown says about China and the world and examine it in the light of what we know about this country and of possible developments in the world as a whole. I make the following conclusions.

1. Brown misjudges China's potential to maintain and indeed increase cereals production because he misinterprets the data on land losses (he treats diversion of land from cereals to, mainly, other crops and aquaculture as if such land were lost to food production), he ignores new data which indicate that China has more agricultural land than reported in official statistics and his projected numbers do not account for responses on the part of producers, consumers and government policy to an increasing scarcity of products and rising prices.
2. The analogies he draws with the experiences of Japan, South Korea and Taiwan are inappropriate.
3. China will probably be a growing net importer of cereals but at levels much below those projected by Brown.
4. World production of cereals may indeed grow at a lower rate than in the long-term past (but not as low as that projected by Brown) which could be sufficient to accommodate China's growing import requirements and the probable ones of other countries.
5. The world food problem is one of persistence of very low food consumption levels and high incidence of undernutrition in many developing countries, mainly in sub-Saharan Africa and South Asia.

The persistence of severe food insecurity problems reflects not so much constraints in increasing food production in the world as whole but development failures (often agricultural development failures) and the persistence of poverty in certain countries.

1. Introduction

Lester Brown's writings about trends in China's food consumption, production and rapidly rising import requirements (Brown, 1994a,1995) and his predictions that the world is running out of potential to increase production of cereals received wide publicity in the press. This created an awareness of the problem among the public, which was stimulated by

[1] The views expressed in this paper are the author's and do not necessarily reflect those of FAO. All data in this paper are from FAO, FAOSTAT (most of them are available on the Internet: http://www/fao.org) except when otherwise indicated.
This article was prepared by Nikos Alexandratos, Chief, Global Perspective Studies Unit, Economic and Social Department, of the Food and Agriculture Organization of the United Nations (FAO), and is reproduced here by permission of that organization.

[2] E-mail: nikos.alexandratos@fao.org.

PII S0169-5150(96)01191-7

recent declines in world cereals production per capita, falling stocks and sharp rises in world market prices. They also prompted an avalanche of enquiries from journalists, some of which landed on my desk (e.g. NRC Handelsblad, 26 October 1995; Financial Times, 8 March 1996). Then I was asked to produce for this journal a review of Brown's book *Who Will Feed China?* (Brown, 1995). For this purpose I wrote this paper in an attempt to present a coherent picture of what Brown says about China and the world (not an easy task; in what follows all references to Brown's statements are to Brown (1995) except when otherwise stated) and examine it in the light of what we know about this country and of possible developments in the world as a whole. I often have to argue by reductio ad absurdum whenever it appears that Brown's projections do not constitute an internally consistent set. This applies, for example, to his projections of consumption in China and those of production and implied consumption in the world as a whole.

Brown's thesis is easily stated: China's economic growth fuels a rapid growth in food consumption, particularly of livestock products which must be produced with increasing amounts of cereals. But China has little potential for increasing production of cereals, which may actually decline, mainly because of drastic losses of agricultural land and declines in the area devoted to cereals. He predicts that China will replicate the experiences of Japan, South Korea and Taiwan in meeting almost all increases in the demand for wheat and coarse grains through imports. Ergo, China will need to import huge quantities in the future, which will by far exceed the net export availabilities of the rest of the world, particularly in the light of his prediction that world production growth will slow down drastically. The effect will be a scarcity in cereals and rising real prices, with the result that part of the demand of the poor for direct food, and particularly of the import demand of the low-income food importing countries, will be priced out of the market.

Section 2 presents what I understand Brown says about China and Section 3 attempts an evaluation of his statements (demand, production, land use, yields, analogy with experiences of other countries, China's recent experience in cereals trade). Section 4 explores the implications for the rest of the world of Brown's statements about China and the world as a whole. Section 5 discusses the broader world context of developments in production and food security and what other studies say about future prospects. Section 6 examines China's future cereal imports requirements in the context of a set of hypotheses about possible developments in the net trade positions of other major regions. Brief conclusions are drawn in Section 7.

In evaluating Brown's vision of China and the world I use reasoned hypotheses about possible developments in key variables relevant to the matter at hand. The numbers thus generated are not offered as a set of projections for 2030, which can only come from a fully fledged study. Rather, the intention is to show how a more pragmatic line of reasoning generates an alternative framework which is more appropriate for thinking about world food futures and the place of China.

2. Brown's figures for 2030: China

Brown uses the term 'grain' to refer to wheat, coarse grains and rice in milled form. For this reason, his figures are different from those in the Chinese production statistics in which the term 'grains' includes cereals (but with rice counted as paddy) as well as soybeans, pulses and roots and tubers, the latter in grain equivalent at a ratio of 1:5. Thus, 1990 'grain' production in Chinese statistics is given as 446 million tons (Statistical Yearbook of China 1994, table 11.16, hereafter referred to as SYC). In this paper, the term cereals, rather than grains, is used to refer to Brown's definition of 'grains'.

Table 1 (columns 2–4) presents Brown's figures, either explicitly given or implied (see notes to the table). In brief, the author considers that China's cereals production will fall by 20%, from 340 million tons in 1990 to 272 million tons in 2030. Then he confronts his projected production with two assumptions about the growth of demand for 2030 (which he gives to be 346 million tons in 1990): 479 million tons if per capita consumption for all uses stagnated at the 290 kg of 1990; or 641 million tons at a more plausible 400 kg per capita (this implies a

Table 1
Brown's picture of China and the world and (implied) rest of the world: cereals [a]

	China			World		World minus China		
	1990	2030 [b]		1990	2030	1990	2030	
		A	B				A	B
Population (millions) [c]	1193	1602	1602	5285	8671	4092	7069	7069
Cereals								
Production (10^6 tons)	340	272	272	1780	2149	1440	1877	1877
Net imports (10^6 tons)	6	369	207			−6	−369	−207
Consumption, total (10^6 tons)	346	641	479			1434	1508	1670
Consumption per capita (kg)	290	400	290	337	248	350	213	236
Cultivated area, all crops (10^6 ha)	no numbers given							
Sown area, all crops (10^6 ha)	no numbers given							
Cropping intensity (%) [d]	155	decline						
Sown area in cereals (10^6 ha)	90.8	48 [e]	48 [e]					
Implied cereals yield (tons ha^{-1}) [f]	3.74	5.67	5.67					

[a] Cereals include wheat, coarse grains and milled rice.
[b] Projection A is Brown's main scenario (per capita consumption growing to 400 kg). Projection B he gives as an example to demonstrate that China's import requirements would be huge even if per caput consumption stagnated at 290 kg.
[c] China's population derived by dividing Brown's total consumption by his per caput consumption. The 1990 population is 1143 million in the SYC. Note that projection B implies a 2030 population of 1652 million. I ignore this inconsistency in the rest of this paper. World population is from UN (1994a), Medium variant.
[d] Cropping intensity, or multiple cropping index, is the ratio between sown (or harvested) area (in which 1 ha is counted as 2 ha if it produces two crops a year) and cultivated area, in which 1 ha of physical area is always 1 ha.
[e] Implied in Brown's statement that sown cereals area will fall to 0.03 ha per person.
[f] Derived by dividing Brown's projected production by his implied areas sown to cereals.

population of 1.6 billion) [3]. The net import requirements for 2030 work out as 207 million tons and 369 million tons, respectively. The author considers that China will go the way of Japan, South Korea and Taiwan, which have had rapidly increasing grain imports because, like them, it has entered a phase of rapid growth of incomes and shifts of consumption towards livestock products in conditions of acute land scarcities and even more acute water scarcities. He considers that these projected deficits are reasonable if judged by what he terms a 'reality check', that is "...what China's grain imports will be in 2030 if its dependence on imports is similar to that of Japan, South Korea and Taiwan today" (p. 97). He concludes that, by this yardstick, China's net imports in 2030 would be 280, 363 or 333 million tons, respectively. He derives these numbers by multiplying Japan's net imports of 28 million tons in 1990 by 10 which, he says, is the ratio of China's population to that of Japan in 1990, and so on for the other countries. However, correct application of his 'check' would require multiplication by the ratio of China's population in 2030 to that of Japan's in 1990 since this criterion implies that the per capita net imports of China in 2030 would be equal to those of Japan in 1990 (230 kg in 1989–1991), or Korea (230 kg) or Taiwan (305 kg). This calculation would have yielded net imports for China in 2030 in the range 350–470 million tons, on the basis of the above-mentioned population of 1535 million.

3. Evaluation

3.1. Demand

My understanding is that Brown's first alternative of constant per capita consumption of 290 kg is

[3] See footnote b in Table 1. The latest UN population projections (UN, 1994a, medium variant), give population sizes of 1155 million for 1990 and 1554 million for 2030 (note that this includes Taiwan—population 20 million in 1990). In what follows, I will use a population projection for 2030 of 1535 million for China.

Table 2
China's land data (million ha)

	1983–1985	1991–1993	Annual change
Cultivated area	97.7	95.4	−0.3
Total sown area	143.9	148.8	+0.6
Area sown in grains (cereals, roots and tubers, soybeans, pulses)	111.9	111.1	−0.1
Of which in cereals [a]	90.6	90.3	–

Source: Statistical Yearbook of China, 1994 (Beijing, 1995).
[a] Chinese data for sown area in wheat, rice, maize, sorghum and millet, supplemented by FAO estimates for the other coarse grains (barley, rye, oats, buckwheat, triticale).

given just for illustration, so the second alternative of 400 kg is more relevant. How relevant it is depends on the extent to which it suffices to support the growth of animal production required to sustain a more than doubling of consumption per capita of livestock products. Simpson et al. (1994) (p. 296) estimate that China uses about 75 million tons of cereals (including some 13 million tons of whole and broken rice in milled equivalent) for livestock feed. This translates into 66 kg per capita, leaving 224 kg for food and other uses. Assuming this latter number to remain constant (with declines in direct food use compensated by increases in the uses for beer or aquaculture feed), then per capita use for livestock feed would have to increase from 66 to 176 kg (an increase of 165%) to deliver Brown's 400 kg by 2030. This would be sufficient to more than double the 1990 levels of per capita production of livestock products (26 kg of meat, 5 kg of milk and 6 kg of eggs) considering that there is significant scope for productivity increases in animal production [4]. Overall, therefore, the 400 kg per capita projected by Brown seems to contain a sufficient allowance for the feed requirements to meet a more than doubling of per capita consumption of livestock products. Projections by the International Food Policy Research Institute (IFPRI) have China's per capita consumption of cereals rising to 360 kg in 2020 (Rosegrant et al., 1995). OECF's recent study projects for 2010, 328 kg of milled rice, wheat and maize (OECF, 1995, tables 11 and 17). In what follows I will use Brown's number of 400 kg per capita but multiply it by the UN population projection to yield an aggregate consumption of 614 million tons for 2030.

3.2. Production

Brown's main reasons for projecting declines in cereals production are: (a) cultivated land (physical area: latest SYC estimate 95.1 million ha in 1993) and/or area sown in cereals (which includes multiple cropping: latest SYC estimate 88.9 million ha in 1993) will decline drastically, and (b) yields are already high, so there is only limited scope for further growth.

3.2.1. Land

There are a number of problems with the cultivated land data. For one thing, the SYC (table 11.3) contains the following warning "figures for the cultivated land are under-estimated and must be further verified". Brown does not warn the reader that this pivotal variable in his argument might be seriously flawed, except in passing, by stating that "if China's cropland area is underreported for tax reasons, then yields are overstated, leaving more potential to boost yields" (pp. 77–78). Indeed, he talks a lot about losses of cropland but in his Chapter 4 (The Shrinking Cropland Base) he does not give even one figure for total cropland or cultivated land and all his numbers refer to (harvested) grainland. For another, he exaggerates the land losses and deals with the reduction in area sown to cereals, by 1.26 million ha p.a. according to him (p. 27), as if it were equivalent to loss of cultivated land, since much of his discussion is about conversion to non-agricultural uses.

[4] Simpson et al. (1994) (tables 7.7, 8.1, 12.9) estimate that increases in livestock output (meat by 220%, milk by 525% and eggs by 145%) between 1990 and 2025 could be obtained by an increase in the cereals used for feed of only 170%. See also Smil (1995) (p. 812).

That he exaggerates is clear from the SYC data in Table 2 on changes in land areas between the 3 year averages 1983–1985 and 1991–1993 (1993 being the last year with data in the SYC 1994).

Thus, total sown area actually increased while that for cereals remained constant, which means that other crops (oilseeds, sugar, fruit and vegetables, tobacco) increased their share in total sown area, a positive development in itself, except, of course, for tobacco. It is true that the SYC data show a cumulative 'decrease in cultivated area' between 1983 and 1993 of 7.5 million ha, but apparently this refers to gross conversion of land to non-agricultural uses, i.e. not netted for land reclaimed, since in parallel the total cultivated area decreased by only 2.3 million ha. According to Ke (1996), the net reduction of cultivated area between 1978 and 1994 was only 4.5 million ha (which tallies with the estimates of Table 2), while much of the gross reduction has been caused by conversion of cropland to inland aquaculture, i.e. to other forms of food production and not, as Brown claims, to urban development, etc. The way he handles this issue is entirely misleading since he makes appear in a negative light what is in many respects a positive phenomenon, i.e. adaptation of land-use patterns to changes in the structure of food demand, farmer profitability and trading opportunities.

What reduction in the areas sown to cereals underlies Brown's contention that cereals output will decline 20% by 2030? He does not give this number, but it can be derived indirectly from his estimates that such area was 0.08 ha per person in 1990 and will shrink to 0.03 ha per person in 2030 (p. 63), i.e. from 90.8 million to 48 million ha. This is a decline of 1.5% year^{-1}, which nearly tallies with his statement that his estimate of 1.4% year^{-1} decline between 1990 and 1994 "...is likely to endure as long as rapid economic growth continues" (p. 27). He does not say what his assumptions are, if any, about changes in total cultivated area or total sown area for all crops, but he does say that the cropping intensity (ratio of the sown to cultivated area) will decline from the current level of 1.55.

However, I cannot evaluate Brown's projections of declining harvested cereals land without some idea of what may happen to total land. For this we need to have an idea about how serious is the underestimate of the cultivated land data indicated in the SYC. I attempt to do this later, but for the moment I note that Brown's projections of sown land in cereals imply very significant declines in the share of such area to total sown area, perhaps from 60% in 1990 to 40% in 2030. This means that a lot of land will have been shifted to other crops. This is certainly not compatible with Brown's vision of severe scarcities and rising real prices of cereals. On this count alone, Brown's dire predictions of falls in cereals production do not seem to be tenable. He seems to admit as much for the world at large, when he says that "in the real world, the price of grain would rise, reducing consumption and imports while stimulating production and exports until a new balance was reached" (p. 104). But he does not pursue this idea and the reader is left with the impression that this process will not apply to China, in particular that producers and consumers will not respond to the rising prices and that the government will be absolutely absent as a policy-maker.

3.2.2. Yields

It is not clear what Brown assumes about future yields, but the general tone is that there is little scope for further growth, given that China has already high yields. But using his land and production numbers we can deduce that in his projections the average yield would increase from 3.7 tons ha^{-1} in 1990 (or whatever the real yield is) to 5.7 tons ha^{-1} in 2030 (see Table 1). Overall this number is within the realm of realism, so I will use a future yield of 5.7 tons ha^{-1} as a basis for further examination of the production and trade outcomes. I base this judgement on the findings of other studies: for example, a World Bank study (Mitchell and Ingco, 1993) has a projected yield of 5.7 tons for 2010; Simpson et al. (1994) (tables 12.1 and 12.6) project a total cereals yield of 5.2 tons for 2025. Rosegrant et al., 1995 (and personal communication from Mark Rosegrant, 1995) have average cereals yield of 5.2 tons ha^{-1} in 2020. OECF, 1995 (table 12) projects for 2010 a yield of 5.0 tons for wheat, rice and maize (all yields are with rice milled). Ke (1996) considers 'highly possible' yield growth rates of 1.0–1.5% year^{-1} in the next 15 years. FAO's study to 2010 projected China's cereals production directly, i.e. without systematic analysis of the land-use and yield paths (as it

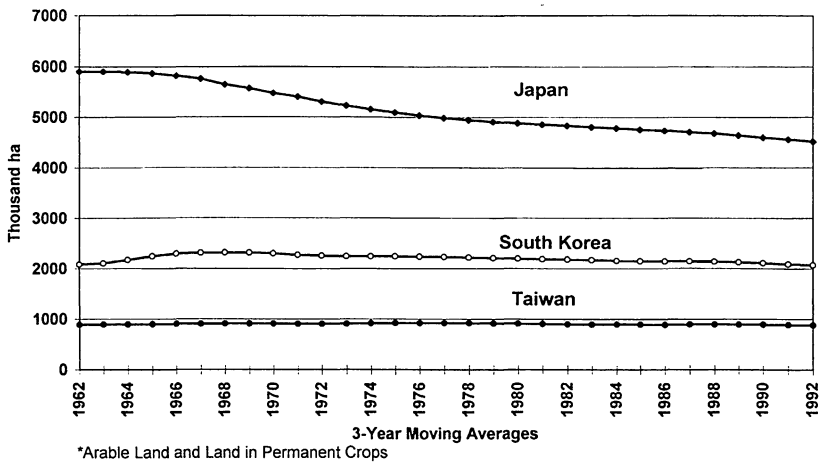

Fig. 1. Agricultural land in Japan, South Korea and Taiwan (arable land and land in permanent crops).

did for the other developing countries), after it became evident that the base-year and historical data of China's land-use and yields did not provide a sufficiently robust basis for such analysis (see Alexandratos, 1995, p. 203).

3.2.3. Accounting for under-reporting land data

As mentioned above, the SYC recognises that the cultivated land data are underestimated. A recent Chinese publication (State Land Administration of the PRC, 1994) seems to confirm what other authors have indicated (e.g. Crook, 1993; Sun Han, 1994; Ke, 1996) and the total cultivated area is reported to be 125 million ha for 1989 compared with 96 million ha in the SYC. In parallel, the data available in Chinese sources of sown areas at the county level indicate a total sown area of 192 million ha (147 million ha in the SYC) for 1989, of which 107 million ha in rice, wheat and maize (83 million ha in the SYC) to which another 7 million ha must be added for the other coarse grains. If these data are close to reality, it follows that average cereal yields are lower (Ke, 1996) or that production is higher than reported in the SYC or a combination of the two. This latter option tends to be embraced by some authors (e.g. Johnson, 1994; OECD, 1995, p. 177).

If the actual situation is as these new data indicate, then the potential for the future cereals production situation to be very different from that depicted by Brown is considerable. One way of thinking about this issue is as follows: assume that (a) the rate of net reduction of cultivated land of the SYC for 1983–1993 (0.3 million ha $year^{-1}$) [5] were to continue up to 2030, reducing total cultivated land from 125 to 113 million ha and (b) the cropping intensity will be reduced by a little to 1.5 by 2030 (Ke, 1996 considers that there is scope for further increase in the cropping intensity, to 1.6). This gives a total sown area of 170 million ha in 2030. The part devoted to cereals was, according to the new data, 60% or 114 million ha in 1989. If 100 million ha were sown to cereals in 2030 [6] at Brown's yield of 5.7 tons ha^{-1}, total production would be 570 million tons. This would leave a net import requirement of 44 million tons in 2030, which is not far from what other studies predict for 2020. Rosegrant et al. (1995)

[5] Garnaut and Ma (1992) (p. 106) project reductions in cultivated area between 1990 and 2000 at the rate of 5 million mu (0.33 million ha) $year^{-1}$. Ke (1996) considers a net loss of 4–5 million ha in the next 15 years to be likely and total cultivated land to be about 120 million ha in 2010.

[6] The OECF Study projects sown area for wheat, rice and maize to decline only marginally — by 3.0% between 1993 and 2010 (OECF, 1995, tables 6 and 12).

and Huang et al. (1995) project 27 million tons and 40 million tons for 2020, respectively (both for baseline scenarios). The OECF study projects a deficit of 65 million tons for 2010 (OECF, 1995: xi; scenario with policy improvements). In what follows I will use 50 million tons for China in 2030 when I confront its import requirements with the world demand–supply balance (Section 6).

3.3. Analogy with experiences of Japan, South Korea and Taiwan

Brown makes much of these analogies on the basis of two similarities: the land scarcity indicators (cultivated land or cereals-sown land per person) and high income growth following industrialisation. The latter is supposed to cause diversion of cultivated land to non-agricultural uses (it has not happened in Taiwan and only to a small extent in South Korea, see Fig. 1) and of land previously under cereals to other crops, as well as declines in cropping intensity. However, there are at least four reasons that make China different from these three countries and can invalidate this analogy.

1. China is a large country and its behaviour in world markets will influence world prices, with the result that any tendency to import large quantities will be mitigated by rising prices through its effects on production and consumption.
2. China is projected to still have in 2030 over 40% of its population in rural areas (starting from 74% in 1990; UN, 1994b). This is twice as high as is currently the case in the other three countries. With these differences, China's agriculture can be expected to have in 2030 a much larger role in national economic life than in these other countries today.
3. The cereals sectors in these countries were overwhelmingly rice-based at the inception of their rapid growth in the imports of wheat and coarse grains to sustain the growth of consumption of these cereals (late 1960s for South Korea and Taiwan, earlier for Japan). In the early 1960s, rice (milled) accounted for 65%, 95% and 76% of total cereals production in the three countries, respectively. By contrast, China has a much more diversified cereals sector at present, with rice accounting for only 37% of total cereals production. Then per capita food consumption of rice declined rapidly (by 55% in Taiwan and 42% in Japan, though it did not decline in South Korea), while that of wheat increased rapidly in all three countries, as did that of coarse grains for feed.
4. The land-scarcity analogy applies with much less force than in Brown's assumption. According to the new land data for China, cultivated land is currently 0.11 ha per person, compared with the values of 0.06–0.08 in these other countries in the mid-1960s.

It is not surprising then, that this combination of initial conditions in Japan, South Korea and Taiwan (rapidly diminishing rural sector, low land/person ratios, limited role of the wheat and coarse grains sector in their agricultural economies) led to nearly all the increases in their consumption of wheat and coarse grains being met by imports and to falls in the amount of land devoted to cereals. Indeed, the decline in the area devoted to cereals in both Japan and Taiwan was partly policy-induced following the decline in rice consumption. Brown interprets this decline to have been caused by diversion of land to non-farm uses. Yet, as noted, there has been no decline in total cultivated land in Taiwan and only a very small decline occurred in South Korea.

Present-day China does not face similar conditions or faces them to a much lesser extent. Its agroecological conditions and tradition in growing wheat and coarse grains, as well as the continued existence of a large rural population (part of which will continue to produce these cereals for their own consumption) indicate that its supply response to increases in demand for these products will be positive. Otherwise, one would have to visualise an increasingly pauperised rural population in the wheat/coarse grains producing regions, an outcome hardly compatible with Brown's vision of rapidly rising incomes and per capita consumption of cereals. It is noted that 50% of the rural population of China is in the predominantly wheat and maize producing provinces, in which rice production (milled) comprises 0% (Shanxi) to 43% (Yunnan) of the combined production of the three cereals (data from OECF, 1995). I conclude that Brown's inferences about the future for cereals in China depend, to an exaggerated degree, on inappropriate analogies with the experiences of these other countries.

3.4. The notion that the process of rapid growth in China's cereal imports has already started

China turned from net exporter in the trade years (July/June) 1992/1993 and 1993/1994 (of 7 and 5 million tons, respectively) to net importer of 12 million tons in 1994/1995 and the forecast for the current year 1995/1996 is for 18 million tons. Brown (p. 100) interprets this turnaround as signalling the initiation of the process that will lead to the burgeoning deficits predicted for 2030. Yet China's status as net importer of 10–15 million tons is nothing new. It had net imports in this range in 2 out of every 3 years in the post reform period to 1992/1993, the year when it turned into a net exporter (see Fig. 2). It may well be that China's net imports of cereals will grow further in the next 5–10 years. The latest USDA projection is that China will be a net importer of 32 million tons in 2005 (USDA, 1996). The projections of Iowa State University's Center for Agricultural and Rural Development (CARD) indicate net imports of 25 million tons for the same year (CARD, 1996), while Ke (1996) considers as probable 40–50 million tons for 2010. The key question is whether these trends of the last few years and what some studies indicate for the medium-term future can be extrapolated for much longer into the future. It is quite possible that China's net import curve will bulge in the short to medium term before it slows down or becomes level. This has been the experience of Japan.

4. Brown's vision for the world as a whole and implications for the world excluding China

Brown is very pessimistic not only about China's potential to increase cereals production, but also about the ability of the whole world to do so to any significant degree. He presents projections (p. 126) showing world production of cereals growing from 1780 million tons in 1990 to 2149 million tons in 2030. This is 0.5% $year^{-1}$ for 40 years and well below the 1.25% $year^{-1}$ growth rate of the world population. The implications are revealed in Table 1 (columns 5–9). Per capita production (= consumption for the world) would decline drastically, from 337 to 248 kg. Who will suffer from the drastic declines in per capita consumption he does not say, but he implies that it will be the poor countries. Take this to mean the developing countries other than China. But these countries have been increasing their per capita consumption (all uses) from 177 kg in 1961–1963 to 214 kg in 1989–1991, while their production grew at 2.8% $year^{-1}$ in the three decades to 1990. Brown's dire predictions for world production imply a drastic reversal of these trends. This by itself is sufficient to demonstrate how unfounded they are, as shown below.

On the most pessimistic of Brown's assumptions (that China's per capita consumption would stagnate at 290 kg), he estimates that China would still consume 479 million tons in 2030, of which 207 million tons will be net imports from the rest of the world.

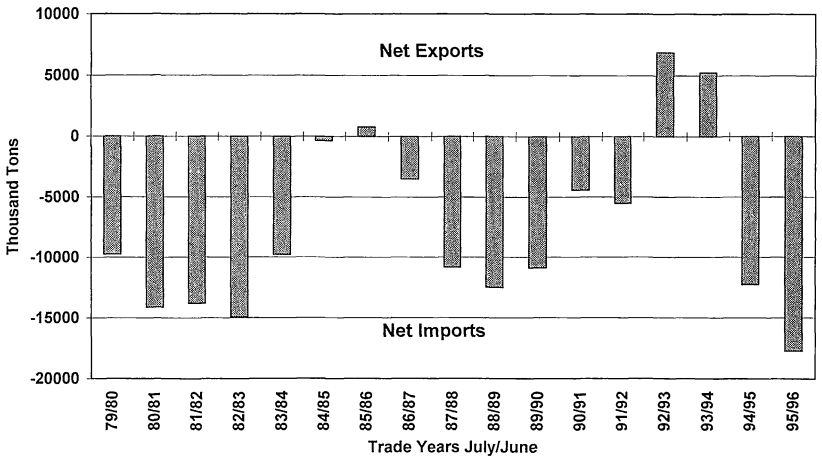

Fig. 2. China's net cereals trade.

Table 3
China's import requirements and net balances of other countries

	1989–1991		Most recent 2 year average, 94/95-95/96 [a]	2030				Population [c] (millions)	
	Total	Per capita	Total	Brown		Hypothetical alternative [b]		1990	2030
	(10^6 tons)	(kg)	(10^6 tons)	Total (10^6 tons)	Per capita (kg)	Total (10^6 tons)	Per capita (kg)		
Net trade									
Developing countries	−89	22	−107	–	–	−320	44	4034	7250
China	−9	8	−14	−207 [d]	130 [d]	−50	33	1135	1535
Brown's group [e]	−31	18	−37	−190	58	−100	30	1758	3280
Others	−49	43	−56			−170	70	1141	2435
E. Europe + former USSR	−37	95	−2			30		388	415
Sub-total	−126	28	−109			−290		4422	7665
W. industrial countries									
Net trade	130		112			290			
Consumption	475	550				630	625	863	1005
Production	598					920			

[a] Years July/June. 95/96 is a forecast.
[b] The projected net import requirements of the developing countries (excluding China) are put intentionally on the high side in order to derive the implications for the required growth of export availabilities and production in western industrialised countries (see text).
[c] Population data and projections (medium variant) from UN (1994a).
[d] Brown's projection B; see Table 1.
[e] India, Bangladesh, Indonesia, Iran, Pakistan, Egypt, Ethiopia plus Eritrea, Nigeria, Brazil, Mexico. These countries account for 61% of the population of developing countries, excluding China, but account for only 39% of their aggregate net imports of cereals.

Subtracting China's consumption from his projected production for the world as a whole, would leave only 1670 million tons for the rest of the world. How will this balance be shared between the developed countries [7] (1989–1991 consumption: 780 million tons or 620 kg per capita) and the rest of the developing countries (1989–1991 consumption: 620 million tons or 214 kg per capita)?

Make the assumption that the total consumption of the developed countries will not increase, even though their populations are projected to grow by 14% between 1990 and 2030 (population projections are given in Table 3). This is less unrealistic than it appears because the reforms in Eastern Europe and the former USSR may lower per capita consumption from the very high pre-reform levels. This will be consequence of reduced livestock production, increased efficiency in the use of cereals for feed and reductions in overall food losses. A lower per capita consumption in this region would contribute to maintaining that of the developed countries as a whole at nearly present levels, even if the per capita consumption of the industrial countries of the West were to rise (see Table 3). This would leave 890 million tons (1670 minus 780) for the developing countries (excluding China) in 2030. But, in 2030 their populations will total 5.7 billion and, by implication, their per capita consumption will fall from 214 to 156 kg. For this to happen, we would have to assume that the growth rate of cereals production in these countries (which include India, Indonesia, Turkey, Latin America, etc.) would decline to only 0.35% year^{-1} and that they would suffer catastrophic reversals in their overall development trends. This growth rate is computed as follows: in 1989–1991 the developing countries (excluding China) produced 540 million tons of cereals and had net imports of 75 million tons. Their imports are going to increase in the future. The IFPRI study projects such imports to be 166 million tons in 2020 (Rosegrant et al., 1995). Brown projects much faster growth (see below, Table 3). On the over-generous (for Brown's thesis) assumption that the net imports of the developing countries (excluding China) will increase to 270 million tons by 2030, their production must increase to 620 million tons to be compatible with the above mentioned consumption of 890 million tons. This implies a growth rate of 0.35% year^{-1} for 1990–2030. However, as noted, these countries experienced the very respectable average growth rate of 2.8% year^{-1} in the three decades to 1990 in their cereals production. Even in the last 5 years (1990–1995) they had a growth rate of 2.3% year^{-1}

I conclude that Brown's apocalyptic vision of the future, based as it is on such unrealistic assumptions, will probably fare no better than his earlier predictions of impeding catastrophe, e.g. his prediction that real food prices would continue to rise (conditional to demand growing '...as now projected'), made at the peak of prices in 1974 and just before the resumption of their long-term downward trend (Brown and Eckholm, 1974, p. 246; in practice, world consumption grew 2.3% year^{-1} in 1974–1990 with prices declining) or that the trend for yields to rise in the USA, France and China was coming to an end in the late 1970s (Brown, 1981; I owe this reference to D. Gale Johnson). In practice, the 3 year average per hectare yields (with rice in paddy) rose from 3.8 tons in 1976–1978 to 5.1 tons in 1992–1994 in the USA, from 4.0 to 6.5 tons in France and from 2.6 to 4.5 tons in China.

5. The broader world context

Brown is vehemently critical of any statement that the world is likely to continue to make progress on the food front, slow and uneven as it may be, and chooses to misinterpret what other people say. He has this to say (p. 125):

''...many people thought that the steady growth in both oceanic and land-based food production would continue more or less indefinitely. Among those making this assumption were those responsible for making world food supply and demand projections at the UN Food and Agriculture Organization and at the World Bank. One result of the simple extrapolation exercise they engage in is that they yield 'no problem' projections, thus lulling the world into a false sense of complacency.''

[7] In this discussion, the term developed countries includes North America, W. Europe, E. Europe and former USSR, Japan, Australia, New Zealand, Republic of South Africa and Israel (the term Western Industrial countries is used to refer to the developed countries other than E. Europe and former USSR). The rest of the world is in the 'developing countries' category.

Nothing could be further from the truth. The World Bank study (Mitchell and Ingco, 1993) covers only cereals, certainly not fisheries, and it projects not 'steady growth' in world cereals production (2.6% year^{-1} in 1961–1990) but a significant slowdown to 1.3% year^{-1} for 1990–2010. The FAO study (Alexandratos, 1995) does cover fisheries (it has a whole chapter on the sector) and it makes the point that there is very limited scope for increasing catches in marine capture fisheries, though more scope for growth of aquaculture; and, like the World Bank, it projects a drastic slowdown in world cereals production to 1.6% year^{-1} from 1988–1990 to 2010 (p. 118). Comparisons of the projections of these two studies, as well as of a study by IFPRI, are given in Islam (1995) (pp. 86–87). All three studies make the point that the slowdown in the growth of production in the world as a whole reflects mainly a slowdown in the growth of effective demand (see below).

Brown's apocalyptic vision of world food prospects is in line with his arguments propounded elsewhere (e.g. Brown, 1994b, Chapter 10; Brown and Kane, 1994). These interpret the decline in world per capita production of cereals after the mid-1980s to be (a) the result of increasingly binding production constraints (land, water, technology) in the world as a whole, and (b) indicative of things to come. One cannot but agree with the proposition that land and water resources are becoming increasingly scarce (by definition, if considered in per capita terms). However, the key question is whether they are sufficient, or can be made so through productivity-increasing investment (agricultural research, more efficient irrigation, etc.), to sustain world production growth at the rate required to match that of effective demand, at notionally non-increasing real prices. All three above-mentioned studies answer this question in the affirmative, in part because they project future growth of world effective demand to be lower than in the past. The World Bank and IFPRI studies project prices to decline in real terms (the FAO study did not project prices). However, theirs are far from being 'no-problem' projections as they imply persistence of grossly inadequate food consumption levels and of significant undernutrition in the poor countries.

A more relevant question is whether the world could produce enough to also cover the food consumption needs (rather than only the projected effective demand) of the latter countries, say raise their per capita consumption of cereals to 300 kg year^{-1}. The answer depends on the time horizon over which such additional demand may materialise. For example, with per capita consumption of cereals of China at 400 kg in 2030 and that of the developed countries maintained at the current level of 620 kg (see above), world production would need to be 3.2 billion tons if the rest of the developing countries were to raise per capita consumption for all uses from today's 214 kg to 300 kg, a level usually associated with a sufficient diet, though not very intensive in livestock products (the population projections used in these calculations are shown in Table 3). These numbers result in an average per capita consumption (all uses) for all the developing countries including China of 320 kg in 2030. A benchmark number of about 350 kg for the developing countries ('for a well-fed world') in 2025 is used in a recent CGIAR study (CGIAR, 1994, p. 28).

The required growth rate of world cereals production from 1990 to 2030 would be 1.5% year^{-1}. Not having done a detailed evaluation that far into the future, similar to that of the FAO study to 2010 (Alexandratos, 1995), I cannot tell whether this growth rate could be forthcoming and at what prices. I note however that 1.5% year^{-1} is well below the historical growth rate of the preceding 3 decades (2.6% year^{-1} in 1961–1990) which was achieved with falling prices. Of the three above-mentioned studies, that of IFPRI (Rosegrant et al., 1995) has the longest time horizon and projects, in what is essentially a demand-constrained scenario for the world as a whole, an average growth rate of world cereals production of 1.5% year^{-1} and further price declines between 1990 and 2020 (baseline scenario).

I conclude that unless all existing detailed studies (which, of course, assume continued efforts to maintain and upgrade the world's food production capacity, e.g. investment in agricultural research, extension services, increased efficiency in water use, etc.) got things terribly wrong, the capacity of the world as a whole to produce more food may not be the binding constraint to improving the food security of the low-income countries. It is rather the evolution of the situation in these latter countries, mainly as regards incomes and poverty, that will determine the

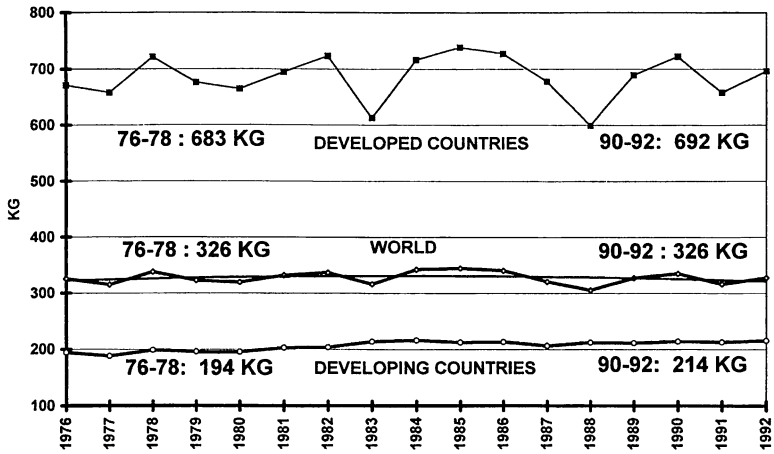

Fig. 3. Per capita production of cereals.

outcome. The majority of these countries are characterised by a high dependence on agriculture, particularly as regards the proportion of their population (indeed, of the population below the poverty line) depending on the sector for a living, directly and indirectly. It follows, almost axiomatically but also supported by empirical evidence (World Bank, 1995), that success or failure in their own agricultural development will be of primary importance in their efforts to achieve poverty-reducing economic growth in a way that stimulates both the demand and the supply of food and improves food security. If some of these countries face difficult-to-overcome natural resource constraints (e.g. prevalence of semi-arid agriculture, overall land and water scarcities) it is quite legitimate to say that progress towards improved food security is impeded by difficulties in increasing food production locally, a trivial statement in itself. But this is not equivalent to saying that lack of progress towards enhanced food security is due to the lack of capacity of the world as a whole to increase food production.

There is another sense in which world level indicators, in particular those of world averages, may convey only limited information useful for diagnosing food security trends. This is the interplay between, on the one hand, the highly unequal initial conditions between different country groups (e.g. the per capita cereals consumption of sub-Saharan Africa and South Asia of 165 kg and those of the developed countries—620 kg) and, on the other hand, their widely differing population growth rates. Such interplay makes it possible for both groups to achieve improvements in per capita consumption even if the

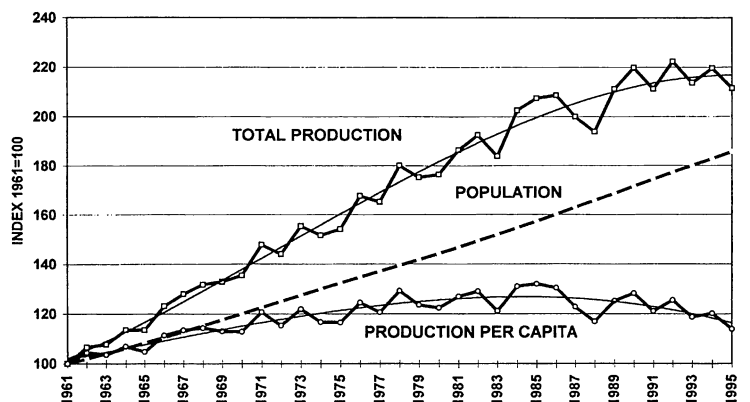

Fig. 4. World cereals production, 1961–1995 (expressed in relation to production in 1961).

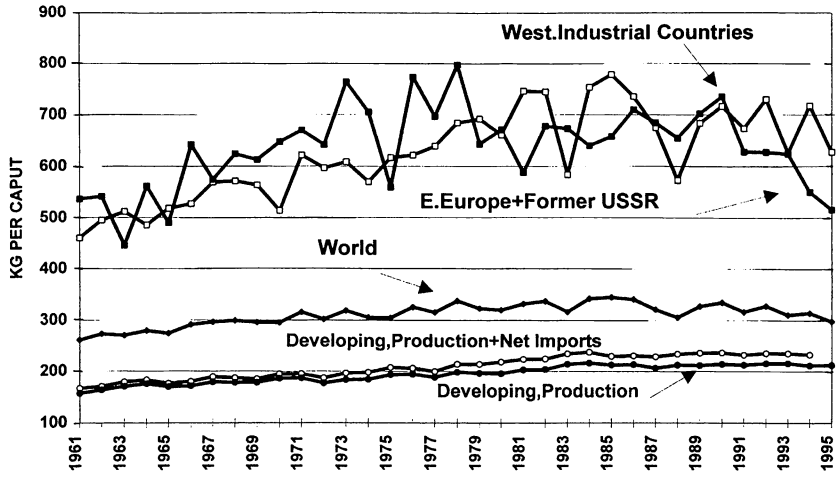

Fig. 5. Cereals production (kg per capita).

world average remained constant, or even with a declining world average. Fig. 3 illustrates this case for the period between the 3 year averages 1976–1978 and 1990–1992 when per capita cereals production increased in developed and developing countries but the world average did not increase.

I conclude that world average indicators are of limited value for drawing inferences about progress or otherwise in world food security. Even if a 'cereals only' indicator were representative of total food (which it is not, see below), it should be observed at a fairly disaggregated level for interpreting current developments and assessing their relevance for future trends. Figs. 4 and 5 present relevant information for cereals. It is obvious that much of the decline in world per capita production reflects the drastic falls in Eastern Europe and the former USSR, a development upon which I need not dwell except to point out that it cannot be considered to be permanent or indicative of things to come for the world average. Fig. 5 is intentionally expressed in absolute (kg per capita) rather than relative values, in order to highlight the real underlying problem in world food security—the very low per capita production and consumption levels of the developing countries. Even this average for the developing countries understates the real magnitude of the problem because it does not show that sub-Saharan Africa has per capita consumption of only 130 kg (a figure which, however, overstates the problem, given the

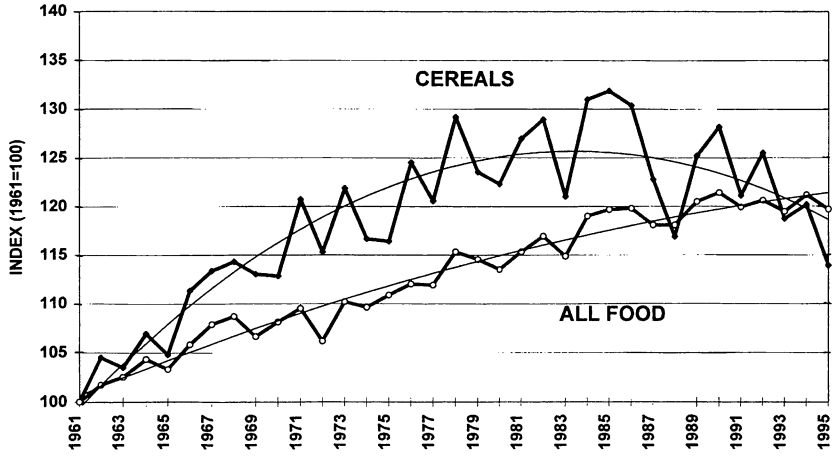

Fig. 6. Per capita production of cereals and all food, for the world as a whole, 1961-1995 (expressed in relation to production in 1961).

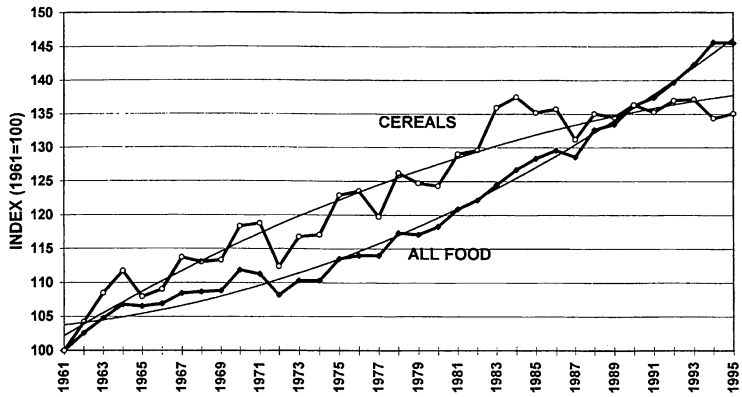

Fig. 7. Per capita production of cereals and all food, in developing countries, 1961–1995 (expressed in relation to production in 1961).

importance of roots, tubers, and plantains in the region's food consumption) and South Asia only a little more (180 kg).

However, a 'cereals only' indicator, although widely used, is not very representative of developments in total food production because the per capita production of other food items (sugar, oilseeds, livestock products, fruit and vegetables) grew faster than that of cereals after the early 1970s for both the world as a whole and the developing countries. These developments are shown in Figs. 6 and 7.

6. China's import requirements and world trade balance

In addition to his estimates for China, Brown thinks that the net import requirements of other developing countries will also be huge. He presents projections for a set of the largest developing countries outside China (see Table 3) showing their net imports rising from 32 million tons in 1990 to 190 million tons in 2030 (p. 115). He has abandoned the estimate presented in the 1994 article version of his book (Brown, 1994a) that Africa alone is expected to need net imports of 250 million tons by 2030 (for a critique, see Alexandratos and de Haen, 1995). The true situation is that Brown's large developing countries had net imports of cereals of only 18 kg per capita in 1989–1991 and this was 19 kg in 1979–1981 and 12 kg in 1961–1963.

The implications for 2030 are presented in Table 3, which also shows a hypothetical alternative projection (intentionally over-generous for Brown's thesis). Briefly, the population of the countries in Brown's group will be 3.3 billion in 2030 and his projection implies that their per capita net cereals imports would rise to 58 kg. Given the past behaviour and proven capability of several of them to keep close to 100% self-sufficiency as well as the little probability that India (48% of the group's population) would shift much towards a livestock-based diet, it would be surprising if their per capita imports increased by much. Even if they grew to 30 kg, their net imports would rise to 100 million tons. The other developing countries (all developing countries minus China minus Brown's large countries) had per capita net imports of 43 kg in 1989–1991, up from 31 kg in 1979–1981. Their populations will total 2.4 billion in 2030. If their per capita imports increased to 70 kg, their net imports would amount to 170 million tons in 2030. Summing the net imports of the three components, i.e. China (50 million tons), Brown's large developing countries (100 million tons) and the other developing countries (170 million tons), we obtain net import requirements of the developing countries of 320 million tons in 2030.

Would this be too large an exportable surplus for the developed countries to generate in 2030? In 1989–1991, the Western industrial countries (largely the OECD area) had net exports of 130 million tons, of which 37 million tons were absorbed as net imports by the former USSR and Eastern Europe. These latter countries have reduced their net imports to only 2 million tons in the most recent 2 year average 1994/1995–1995/1996 (see Table 3). It is likely that in the future they could turn into net

exporters (Johnson, 1993). The above mentioned World Bank study (Mitchell and Ingco, 1993) projects net exports for this region of 15 million in 2010. The same number is projected by the IFPRI study (Rosegrant et al., 1995) but for 2020. CARD (1996) projects net exports of 11 million tons in 2005. If the net exports of this group of countries were to be 30 million tons in 2030, then the Western industrial countries would need to increase net exports from the 130 million tons of 1979–1981 to 290 million tons in 2030 in order to meet the above mentioned net imports of the rest of world. Given the very slow growth of their domestic demand (assumed to grow at no more than 0.7% $year^{-1}$, given that their population growth rate for 1990–2030 is projected to be 0.4% $year^{-1}$), increasing their exportable surplus to 290 million tons would require a growth rate in production of 1.1% $year^{-1}$ for 1990–2030.

The extent to which this is possible without putting great strain on their production system is a matter of conjecture. Among those who have addressed this issue in a long-term perspective, the IFPRI study projects a production growth rate of the OECD area of 0.9% $year^{-1}$ for 1990–2020 (Rosegrant et al., 1995, table 10). However, this reflects more than anything else a demand constraint, as the study projects year 2020 net imports of all the developing countries of 188 million tons, a far cry from the intentionally over-generous level of 320 million tons for 2030 I use here. A very recent study on the European Union considers that under appropriate policies (no land set-asides but also no price supports) the wheat production of the EC-9 could increase at 2.0% $year^{-1}$ and that of coarse grains at 1.0% $year^{-1}$ from 1992 to 2020 (Folmer et al., 1995, table 7.3). The implication is that the EU could develop into a growing net exporter of cereals, with net exports above the limits for subsidised exports permitted under the Agreement on Agriculture of the Uruguay Round. A similar conclusion is embodied in the above-mentioned USDA projections (USDA, 1996) as well as in those of CARD (1996), with part of the EU's exports being effected without export subsidies already in 2005. Overall, therefore, a production growth rate of 1.1% does not seem outside the realm of possibility. On more likely and less generous assumptions (for Brown's thesis) about the import requirements of the other developing countries, such growth could easily accommodate Chinese net imports well above the 50 million tons used here.

7. Conclusions

China will probably be a growing net importer of cereals in the future. However, government policy and the response of producers and consumers, in China and elsewhere, to eventual scarcities and rising prices will tend to bring about balance at import levels that are likely to be only a fraction of those projected by Brown for 2030, though the country's import curve may bulge in the short to medium term. China's growing import requirements will be a problem for the world only if the rest of the world suffered the catastrophic declines in the growth rate of cereals production projected by the author, as well as the reversals in more general development trends implied by Brown's vision of declines in food consumption. That this is an unlikely outcome was demonstrated earlier with reference to the implausible production–consumption implications for major country groups. That the growth rate of the world production of cereals may be lower in the future compared with the past is not in dispute. This slowdown reflects both good and bad developments in the world food scene. The good ones are the slowdown in population growth and the growing proportion of world population which has attained or will gradually attain relatively high consumption levels. Both contribute to a slowdown in the growth of demand. The experience of the developed countries, whose per capita consumption remained constant in the 1980s, is instructive. But these latter countries still account for 45% of world consumption. This means that aggregate world consumption trends are greatly influenced by the fact that only just over one half of it has significant potential for further growth.

The bad aspect of world demand slowdown is that it also reflects the fact that the incomes and agricultural production in the countries with grossly unsatisfied food needs (e.g. in sub-Saharan Africa, South Asia) are not growing at rates anywhere near those required to boost their demand for food and solve their nutrition problems in the foreseeable future. For

example, the latest World Bank assessment foresees only sluggish growth in the per capita GDP of sub-Saharan Africa for the next 10 years (World Bank, 1996). It is the situation in these countries, particularly those in which progress in raising incomes and food supplies depends predominantly on the performance of their own agriculture, that must attract the attention of those concerned with the solution of the world food problem. This point is also made forcefully by Paarlberg (1996). I leave it to the reader to decide whether Brown's exaggerated claims about China and the world as a whole contribute to the debate concerning the countries with severe food security problems.

Acknowledgements

I thank D. Gale Johnson (University of Chicago), Claude Aubert (INRA, France), M. Rosegrant (IFPRI), J. Bruinsma, P. Konandreas and several other colleagues in FAO for their helpful comments. Responsibility remains mine. An earlier, reduced version of this paper was published in *Chinese Rural Economy* (Vol. 4 1996, in Chinese).

References

Alexandratos, N. (Editor), 1995. World Agriculture: Towards 2010, An FAO Study. John Wiley, Chichester, UK and FAO, Rome (published also in French by Polytechnica, Paris and in Spanish by Mundi-Prensa Libros, Madrid/Mexico).

Alexandratos, N. and de Haen, H., 1995. World consumption of cereals: Will it double by 2025? Food Policy, August.

Brown, L., 1981. The worldwide loss of cropland. In: R. Woods (Editor), Future Dimensions of World Food and Population. Westview Press, Boulder, CO.

Brown, L., 1994a. Who will feed China? World Watch, September/October.

Brown, L., 1994b. State of the World 1994. W.W. Norton, New York.

Brown, L., 1995. Who Will Feed China? Wakeup Call for a Small Planet. W.W. Norton, New York.

Brown, L. and Eckholm, E., 1974. By Bread Alone. Praeger, New York.

Brown, L. and Kane, H., 1994. Full House: Reassessing the Earth's Population Carrying Capacity. W.W. Norton, New York.

CARD, 1996. FAPRI 1996 Baseline Briefing Paper (CNFAP 9-96), Center for Agricultural and Rural Development, Iowa State University, Ames.

CGIAR, 1994. Sustainable agriculture for a food-secure world: A vision for international agricultural research, a statement by an external panel appointed by the CGIAR Oversight Committee —G. Conway (Chair), July.

Crook, F., 1993. Underreporting of China's cultivated land area: Implications for world agricultural trade. In: International Agriculture and Trade Report, China. Doc. RS-93-4, ERS, USDA, Washington, DC.

Folmer, C., Keyzer, M., Merbis, M., Stolwijk, H. and Veenendaal, P., 1995. The Common Agricultural Policy Beyond the McSharry Reform. Elsevier North Holland, Amsterdam.

Garnaut, R. and Ma, G., 1992. Grain in China. Department of Foreign Affairs and Trade, Canberra.

Huang, J., Rozelle, S. and Rosegrant, M., 1995. Supply, demand and China's future grain deficit (draft). IFPRI, Washington, DC.

Islam, N. (Editor), 1995. Population and food in the early Twenty-First Century. IFPRI, Washington, DC.

Ke, B., 1996. Grain production in China: Current trends, potentials and policy options. Paper presented at the Conference on Feeding China: Today and into the 21st Century, Harvard University, 1–2 March.

Johnson, D. Gale, 1993. Trade effects of dismantling the socialized agriculture of the former Soviet Union. Comp. Econ. Stud., 35: 4.

Johnson, D. Gale, 1994. Does China have a grain problem? China Econ. Rev., 4: 1.

Mitchell, D. and Ingco, M., 1993. The world food outlook. The World Bank, Washington, DC.

OECD, 1995. Agricultural policies, markets and trade in the central and eastern European countries, selected new independent states, Mongolia and China. OECD, Paris.

OECF, 1995. Prospects for grain supply–demand balance and agricultural development policy in China. Overseas Economic Cooperation Fund, Tokyo.

Paarlberg, R., 1996. Rice bowls and dust bowls: Africa, not China, faces a food crisis. Foreign Affairs, 75 (3) (May/June).

Rosegrant, M., Agcaoili, M. and Perez, N., 1995. Global food projections to 2020: Implications for investment. IFPRI, Washington, DC.

Simpson, J., Xu Cheng and Miyazaki, A., 1994. China's livestock and related agriculture, projections to 2025. CAB International, Wallingford, UK.

Smil, V., 1995. Who will feed China? China Q.: 801–813.

State Land Administration of the PRC, 1994. China, Land Resources, Use and Productivity Assessments Project. Main Report, Beijing.

Sun Han (Editor), 1994. Agriculture, Natural Resources and Regional Development in China. Jiangsu Science and Technology Press, Nanjing. (In Chinese.)

UN, 1994a. World population prospects, the 1994 revision, annex tables. UN, New York.

UN, 1994b. World urbanization prospects, the 1994 revision, annex tables. UN, New York.

USDA, 1996. Long-term agricultural projections to 2005. Staff Rep. WAOB 96-1, Washington, DC.

World Bank, 1995. A strategic vision for rural, agricultural and natural resources activities of the World Bank. World Bank, Washington, DC.

World Bank, 1996. Global economic prospects and the developing countries. Washington, DC.