World Food Trends: A Neo-Malthusian Prospect?[1]

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> In an endeavour to determine the natural power of mankind to increase, as well as their power of increasing the produce of the soil, we can have no other guide than past experience.
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> —*T. R. Malthus* (1830 [1970, 225])

THOMAS ROBERT MALTHUS will forever be associated with *An Essay on the Principle of Population* (the so-called *First Essay*), which was published anonymously in 1798. With its polemical flavor, this pamphlet caused an instant stir and made its author famous.

Malthus's purpose in writing the *First Essay* was to argue against various visions of the perfectibility of society—in particular those of William Godwin and the Marquis de Condorcet. His central argument related to the differential powers of population and agricultural production. Using some of the best-known words in all of social science he stated that "[p]opulation, when unchecked, increases in a geometrical ratio. Subsistence increases only in an arithmetical ratio. A slight acquaintance with numbers will shew the immensity of the first power in comparison of the second" (Malthus 1798 [1970, 71]).

By the word "subsistence" Malthus was referring mainly to the production of *food*. He was well aware that more food could be produced if more land could be brought into cultivation. However, his argument in this passage was based upon the presumption that the supply of land is ultimately fixed. So, in modern parlance, he was referring essentially to the form of growth of agricultural *yields* (i.e., output per unit of harvested area). Basically he was suggesting that yield

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growth tends to be *linear* in form, while drawing upon the experience of the infant United States—"where the means of subsistence have been more ample" (1798 [1970, 74])—under certain conditions populations could grow *geometrically*, at least for limited periods of time. Unfortunately, interpretations of Malthus's statement often overlook the two crucial words "when unchecked." For in fact Malthus believed that most populations were checked in a variety of ways for most of the time. It was only in certain circumstances that a population might temporarily outgrow its food supply and that famine might act as "the last and most dreadful mode by which nature represses a redundant population" (Malthus 1798 [1970, 109]).

That said, for much of the time since 1798 Malthus's name has been linked to the idea that the population of the world might outgrow its capacity to produce enough food—so raising the specter of massive famines. For example, at a conference in 1948 Lord Boyd Orr (who during 1946–47 was the director general of the newly created Food and Agricultural Organization [FAO] of the United Nations [UN]) stated that "exactly a hundred and fifty years ago a reverend gentleman called Malthus wrote a pamphlet pointing out that the population of the world was growing, that the physical capacities were limited, and that a stage would soon be reached where there was not sufficient food to feed the world" (quoted in Flew 1970, 7). And today prominent environmentalist writers still cite the name of Malthus in a broadly similar vein (e.g., see Brown et al. 1999).

The issue of world food production in relation to population growth is undoubtedly important. Since 1950 the human population has increased from about 2.52 billion to about 6.13 billion (United Nations 1998).[2] And despite a falling *rate* of world population growth, especially in parts of Asia and much of sub-Saharan Africa, there is still very considerable demographic growth yet to come. By the year 2025, the UN projects, global population will be approaching 8 billion. The corresponding "world food problem" too is large and complex. Many of the world's poor subsist on a meager and deficient diet. The Food and Agricultural Organization estimates that today more than eight hundred million people are undernourished, and virtually all of them live in the developing world (FAO 2000a, 1).[3] FAO also estimates that at the start of the year 2000 thirty-two countries faced food emergencies

[2] All the demographic data and population projections used in this paper are taken from this source. The most recent revision of the UN populations projections, just published, is unlikely to change the broad conclusions reached here.

[3] The estimates of the numbers of people who are undernourished cited in this paper relate to 1996–98 and are taken from this source.

of various kinds (FAO 2000b, 2). Some writers have suggested that in the early 1980s the world entered a "new era" in which global grain production will increasingly fall behind population growth (e.g., see Brown et al. 1999, chapter 2; Brown and Kane 1995, 21). World cereal yield growth is said to be in trouble; the average world cereal yield has been characterized as experiencing a "dramatic slowdown," an "abrupt deceleration" since 1984 (Brown and Kane 1995, 142). Looking ahead, some foresee a "demographic trap" in which food production falls in poor countries, death rates rise, and birth rates remain high (e.g., see Brown and Kane 1995, 55; King 1999, 1000). It is this kind of doomsday scenario that is referred to in the title of this paper as a *neo*-Malthusian prospect.

With this as background, the principal purpose of the present paper is to provide a brief overview of world food production trends and prospects. The chief focus will be on cereals. The main cereals are wheat, rice, and coarse grains—which currently represent about 28, 29, and 43 percent of world cereal production respectively.[4] Cereals are the most important food crops. They account for about half of total human calorific intake through their direct consumption (e.g., as cooked rice or bread), and a significantly higher fraction if allowance is made for their indirect intake through the consumption of livestock products (nearly 40 percent of world cereal production is used to feed livestock).[5]

Given the vast and complex nature of this subject, there are no simple answers, and the reader must look elsewhere for analyses of greater depth and breadth.[6] The first part of this paper reviews past trends. The second makes some broad statements regarding medium-term food prospects. The final part concludes.

Recent Trends in Per Capita Cereal Production

Figure 1 shows world per capita cereal production since 1961. Although the world's population doubled during the time-frame shown, it is

[4] All data on cereal production and yields used in this paper (including those used to produce the figures) are in production form (i.e., with rice as paddy). They, and the data on harvested area, have been taken from various years of the FAO *Production Yearbook*, and FAO (1987 and 2001). FAO data for 1999, and particularly the year 2000, are provisional and likely to be revised upwards. That data relating to food production are sometimes *very* rough (especially for developing countries and regions) should require no further emphasis.

[5] On the composition of total human food energy intake, see the data in Alexandratos (1988) and for data on the proportion of grain that is fed to livestock, see World Resources Institute (1996).

[6] This paper draws particularly upon Dyson (1996, 1999). However, for analyses that come to broadly similar conclusions, although from different perspectives, see, for example, Alexandratos (1995), Islam (1994), and Mitchell et al. (1997). Also see the various contributions in Cohen and Federoff (1999).

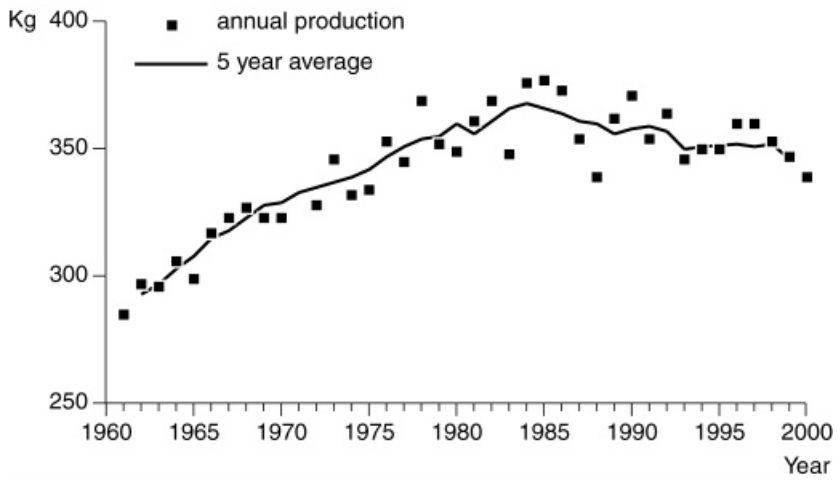

FIGURE 1. World per capita cereal production, 1961–2000

clear that the overall trend in per capita cereal output (as indicated by the moving average) has been upward. So global cereal production has generally grown faster than world population. However, from the early 1980s to the early 1990s there was a modest fall in world per capita cereal output, i.e., cereal production grew slower than the world's population. This fall in per capita output has been interpreted by neo-Malthusian writers in the context of continuing global demographic growth and increasing environmental constraints on world agricultural production (e.g., see Brown et al. 1999; Brown and Kane 1995).

However, for at least two reasons such an interpretation may be somewhat over-simple. First and most important, it overlooks that most of the recent fall in world per capita cereal output has been due to the *deliberate* introduction of restrictions on cereal production in relatively developed regions of the world. Second, it overlooks that the regional composition of the human population is changing. In particular, poor world regions with relatively low levels of per capita cereal production (and consumption) are tending to account for a larger fraction of the world's population. This is because their rates of demographic growth are relatively high. In fact, a fall in world per capita cereal production can be compatible with rising levels of per capita production in various (or indeed all) world regions.[7] Accordingly, trends in per capita cereal production are better considered at a lower level of

[7] This is sometimes referred to as "Simpson's paradox"; see, for example, Alexandratos (1999, 5910).

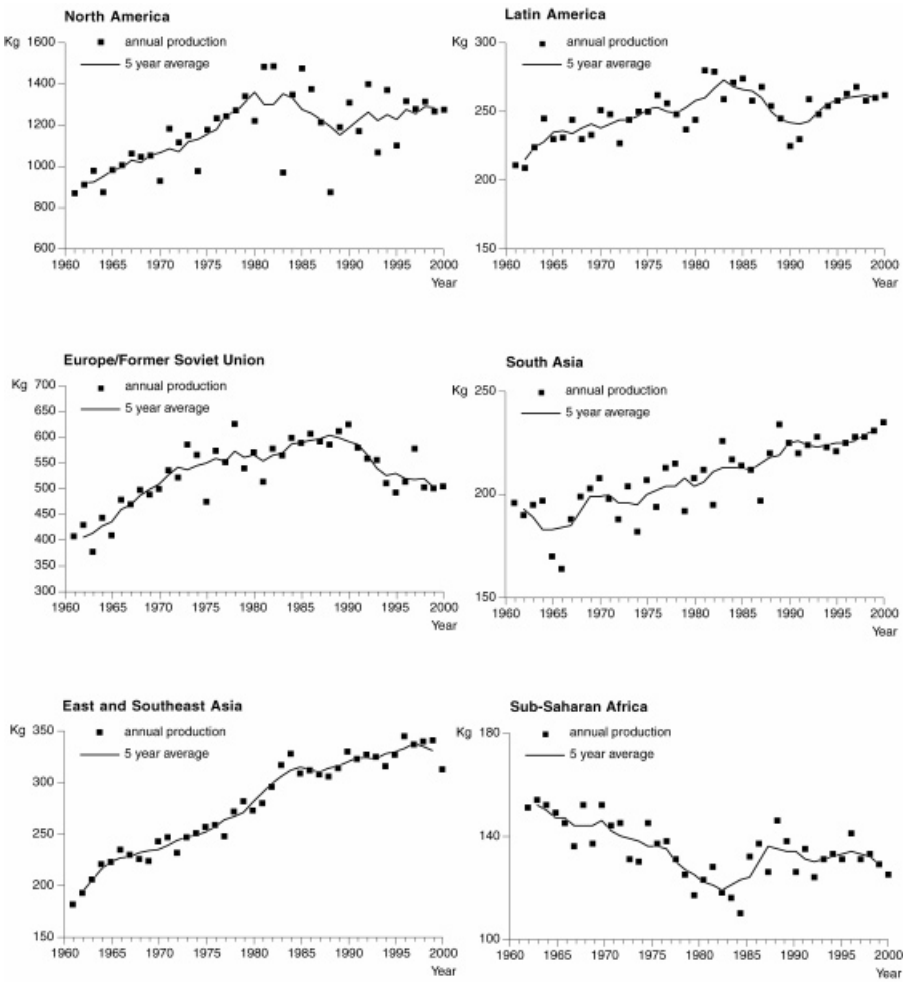

FIGURE 2. Per capita cereal production by world region, 1961–2000

aggregation. In this context Figure 2 plots levels of per capita cereal production for six regions that currently contain more than three quarters of the world's population. We now address the regions in turn.[8]

The United States (U.S.) and Canada make up the first region shown (i.e., North America). These two countries contain only about 5 percent of the world's population. But currently they produce about 19 percent of the world's cereal harvest. Therefore, not only are their asso-

[8] The regions used in this paper are similar to those used in Dyson (1996). Of course there is considerable variation within regions; however, for reasons of space, intra-regional variation is generally neglected here.

ciated levels of per capita cereal output extremely high, but variation in the volume of cereal production in these countries—especially the U.S.—has a major influence upon the level of world cereal output. For the first few decades following the Second World War, these two countries found a ready market for their cereal surplus in Western Europe. But in the 1970s the U.S. and Canada found that this market was closing to them as the European Union (EU) with its subsidizing and protectionist Common Agricultural Policy (CAP) itself emerged on the world scene as a major rival cereal-exporting bloc. Consequently, the first half of the 1980s was a period of rising world cereal stocks and plummeting international cereal prices. Accordingly, the U.S., in particular, took steps to reduce its cereal support costs, decrease its carryover stocks of grain, and promote overseas cereal sales at subsidized prices. Moreover, under a variety of government programs, very large areas of land were withdrawn from cereal cultivation in North America. It was these developments that were the main cause of the fall in world per capita cereal production between the early 1980s and the early 1990s (Dyson 1994, 401–02).

The second region addressed by Figure 2 is Latin America (including the Caribbean). Clearly, average levels of per capita cereal production for Latin America are much lower than those that prevail in the developed countries of North America. However, taken as a whole Latin America is a significant producer of various non-cereal foods (e.g., fruits, vegetables, meat). Therefore, compared to other regions of the developing world, Latin America's general level of per capita food availability is relatively high. And only about 11 percent of this region's people are estimated by FAO to be undernourished. Notice, too, that the overall trend in per capita cereal output shown for Latin America is broadly similar to that shown for North America. Thus, after peaking in the early 1980s, the average level of per capita cereal production in Latin America fell until the early 1990s, before subsequently recovering a little. The explanation for this similarity of trend lies in the previously mentioned changes in international market conditions—in particular, as they affected Argentina. This country is a significant cereal exporter. Faced with a rapidly falling international price for its cereals during the 1980s, and with scant government support, Argentina's farmers had little choice but to shift sizable areas of land out of cereal cultivation.

The third region in Figure 2 consists of the countries of Europe, plus all those of the former Soviet Union (FSU).[9] The European Union was generally slower to respond to the changing international market situation of the 1980s than were the U.S. and Canada. Several consid-

[9] Therefore as defined here this region includes Armenia, Azerbaijan, Georgia, Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan, and Uzbekistan, which are all in Asia.

erations were relevant to this, but they included (i) the particularly strong commitment to agricultural support that was established in Europe following the food crises associated with the Second World War, and (ii) the requirement that a sizable number of nations agree to change the CAP, which is difficult to bring about. By the late 1980s, however, even the EU had to instigate policies to restrict the growth of cereal production, including the idling of significant areas of land. Then in 1991 the sudden demise of communism in eastern Europe and the FSU led to a massive collapse in cereal production, which had a significant additional impact upon the volume of world cereal output. According to FAO statistics, in 1990 the Soviet Union experienced a near-record cereal harvest of about 209 million tons. But by 1995 this figure had fallen to 122 million tons. And the provisional figure for the harvest in the year 2000 is only 119 million tons. These particular figures should be interpreted with caution. But there can be no hiding the scale of the agricultural collapse that has occurred in the FSU since 1991.

The fourth region in Figure 2 is South Asia (i.e., the countries of the Indian subcontinent). This region currently contains about 22 percent of the world's population, and it produces approximately 15 percent of the global cereal harvest. The region is dominated by India, a country that according to FAO contains around a quarter of all the undernourished people in the world (i.e., more than a fifth of the country's population). During recent decades cereal output in South Asia has risen by somewhat more than the population. But the progress has been modest. Thus the average level of per capita cereal output in the region as a whole increased from around 190 kg in the early 1960s to about 220 kg by the 1990s (Figure 2). Major food crises—such as those that affected India in the mid-1960s and Bangladesh in the early 1970s—appear to have been consigned to the past. People's daily food supplies, though often meager, are certainly now more assured. India is more or less self-sufficient in cereals, and the country's current grain stocks are at an all-time high. Clearly, it would be absurd to deny the major food and nutritional problems that are experienced by many people in South Asia. For example, a recent survey in India of ever-married women aged 15–49 years found that 36 percent had a body mass index below 18.5 (the level that is usually taken as indicative of chronic energy deficiency) (IIPS and ORC Macro 2000, 244).[10] But there is no doubt too that the average Indian diet is more diverse now than it was a couple of decades ago, with significantly higher consumption of vegetables, milk, and fruits (Dyson and Hanchate 2000, 4031–33). Moreover, the increases

[10] The BMI is defined as the weight in kilograms divided by the height in meters squared (kg/m^2).

in per capita incomes that have occurred in most parts of the country in recent decades have increasingly tended to be spent on non-food items.

The next region to be considered is East and Southeast Asia.[11] This region currently contains about 31 percent of the world's population and is responsible for about 29 percent of world cereal production. The trend in per capita cereal output shown in Figure 2 largely reflects the experience of China. As can be seen, in recent decades cereal output in East and Southeast Asia has increased significantly faster than has the population. The current level of per capita cereal production is around 330 kg. The initial sharp rise in per capita output shown for the 1960s reflected recovery from the disastrous famine that was associated with China's Great Leap Forward. Notice too the especially sharp rise in per capita cereal output that followed the introduction of the agricultural policy reforms introduced in China around 1978; for the first time during the Communist era it began to pay farmers to grow more food for sale in the market. Furthermore, and to a much greater degree than in South Asia, there is considerable evidence of an increase in the variety of foodstuffs that are grown and consumed. In China there have been sharp rises in the production of vegetables, fruits, sugar, and meat (especially pork) since the early 1980s. Nevertheless, FAO estimates that as of 1996–98 there were still about 140 million undernourished people in China alone.

The last region addressed in Figure 2 is sub-Saharan Africa. Levels of per capita cereal production in this region are extremely low. Moreover, they have generally fallen since the early 1960s. In other words, over this period population growth has outpaced cereal production. Between 1960 and the year 2000, sub-Saharan Africa's population almost tripled (a rise of about 190 percent), but cereal output rose by only about 145 percent. So here perhaps there are some neo-Malthusian resonances. That said, it is important to stress that many factors have contributed to this dismal food production performance. They include widespread poverty, socio-political instability, a frequent neglect of agriculture by governments, and a lack of appropriate agricultural research. While the advances of the so-called "Green Revolution" benefited many farmers in Asia, these same developments were largely irrelevant to farmers in sub-Saharan Africa—who rarely grow wheat or rice (i.e., the main Green Revolution crops) and who have little access to either irrigation or chemical fertilizers. Moreover, that populations in this region have often been growing at annual rates of 3 percent or more (with associated doubling times of twenty to twenty-five

[11] The data for this region used in Figure 2 and discussed in the text exclude Japan.

years) has surely made the task of raising levels of per capita food production harder. Data on agricultural production and harvested area are particularly suspect for this world region. However, it is probable that cereal yields have increased very slowly (if at all) and that much of the rise in *total* food output during the last four decades has come from bringing more land into cultivation (a process that often involves the destruction of savannas and forests). There is no doubt that the agricultural *potential* of sub-Saharan Africa is very high; certainly it is sufficient to feed the region's current population (see Higgins et al. 1981, 13–21). But the realization of this potential is a different matter. FAO estimates that around 1996–98 about one third of the population of sub-Saharan Africa (some 186 million people) was undernourished; this situation may not improve much during the next few decades.

Finally, a word is required about trends in per capita production in the major world region that is not represented in Figure 2. This is the Middle East (i.e., North Africa and West Asia), which contains about 6 percent of the world's population. Since the early 1960s the average level of per capita cereal production in this region has declined slightly from about 275 kg to around 260 kg. The estimated prevalence of undernutrition, however, is broadly similar to that found in Latin America, i.e., about 10 percent. The increase in the price of oil during the 1970s led to a brisk rise in levels of per capita cereal consumption in this region, much of which was *indirect*—i.e., in the form of increased consumption of livestock products. Rising oil revenues at this time were used to purchase large quantities of cereals on the international market, and by 1990 the Middle East relied upon imports to meet almost one third of its total cereal consumption (Dyson 1996, 91). These imports can be seen as one way of helping to circumvent the particularly acute problems of water scarcity for agriculture in this region.

Perhaps three comments about past trends should be made before we turn to a brief consideration of future prospects.

First, the main reason why world per capita cereal production fell after the early 1980s was the deliberate introduction of restrictions on cereal production, particularly in North America, but also in western Europe, plus the major reduction in cereal output that followed the collapse of communism in eastern Europe and the former Soviet Union. These areas of the world generally have relatively slow rates of population growth. The falls in per capita cereal output that occurred were *not* due to increasing environmental production constraints. In North America and the EU—and the few other major cereal-exporting countries—notably Australia and Argentina—cereal yield growth has generally remained very strong in recent years. For example, according to FAO data between 1989–91 and 1998–2000 the average cereal

yield for the U.S. and Canada combined rose from 4.05 to 5.09 metric tons per hectare; for the fifteen countries of the European Union the corresponding figures were 4.79 and 5.64 tons. Restrictions on cereal output were introduced in North America and the EU because, compared to the volume of "effective demand" (i.e., the ability of countries to pay for cereals at the prevailing international prices) the situation was one of global cereal overproduction.

Second, there is considerable evidence that in most parts of the world diets have become more diverse (i.e., more varied) since the early 1980s. This is true for much of Latin America and Southeast Asia (e.g., see Mitchell et al. 1997, chapter 8). The evidence on this for China is also very strong. In this context FAO publishes indices of national per capita *food* production. These indices are calculated using 1989–91 as the base period (i.e., 1989–91 = 100).[12] For China the average figure for the period 1998–2000 is 156, i.e., it is indicative of a more than 50 percent rise in food output per person during the 1990s. To a considerable extent this major increase in food output reflects sharply raised levels of production of sugar, edible oils, fruits, vegetables, meat, and aquatic products. Even in countries where improvements in per capita food production have been much more modest, there are still signs that diets have become somewhat more varied. Thus for India the corresponding index of per capita food production for 1998–2000 is only 106. But, as previously mentioned, the past two decades have seen raised levels of vegetable, milk, and fruit production and consumption. There is evidence that average levels of per capita cereal consumption have actually fallen (Dyson and Hanchate 2000, 4029–31). People have become less keen on consuming traditional coarse grains, and there is now a greater range of foods in local markets. The net effect is that while there has been little change in overall levels of per capita calorie availability, the Indian diet has become more significantly varied (Hopper 1999). Almost all Indian households report that they get "two square meals a day," irrespective of what is indicated by external criteria (Bansil 1999, 47).

Third, trends in average levels of world per capita food production (and consumption) can be misleading. In this context it is important to bear in mind that differential rates of population growth are tending to operate against a reduction in the total *number* of hungry people in the world. This is because rates of demographic growth are generally

[12] To calculate the indices all types of food produced (with deductions for the quantities used as seed and feed) are weighted by the average international prices in the base period and then summed for each year. The index of food production is then calculated as the aggregate for a given year (e.g., 1998) divided by the average aggregate for the base period.

much higher for poor and undernourished populations. Thus, according to FAO, between 1969–71 and 1996–98 the proportion of the population of the developing world that was undernourished fell from 36 to 18 percent (much of this decline was due to developments in China). But the total *number* of undernourished people fell only from 941 to 792 million during this period.[13] Most people who are undernourished either cannot grow enough food for their own consumption, or have earnings insufficient to purchase an adequate amount of food (often both conditions apply). Such people tend to be very poor and uneducated, and they exist in large numbers relative to available employment opportunities—which helps to keep their average wage levels extremely low. Also, a significant fraction of the world's undernourished people inhabit areas where the land and water resources are inimical to major gains in agricultural output. Given these considerations it is hard to deny that there is a demographic dimension to the world food problem.

World Food Prospects over the Medium Run

Several studies have addressed the world's food prospects for the coming two or three decades. Most of these studies focus upon cereals, use similar demographic projections and similar agricultural data, and come to broadly similar conclusions.[14]

There is general agreement that the future evolution of world food demand during, say, the next twenty-five years, will be mainly due to population growth. Thus D. Gale Johnson (1999, 5917) has stated that "[t]he primary factor affecting the growth in demand for food is population growth." As already noted, the world's population will probably be approaching 8 billion by the year 2025. The bulk of this population growth will happen in the world's poorest and worst-fed regions, particularly South Asia and sub-Saharan Africa. It is an unfortunate fact that the poverty and associated low levels of food consumption typical of these regions will operate to limit the future growth of global food demand. In the period to 2025 somewhere between 70 and 90 percent of the rise in world cereal demand is likely to be due to demographic growth.[15]

If population growth is going to be the main element behind the expansion of world food demand over this time horizon, then *yield*

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[13] These figures are derived from Alexandratos (1995, 49–50) and FAO (2000a).

[14] Again, the following discussion is based mainly on Dyson (1996, 1999), but see too the references cited in note 6.

[15] These figures are based on the calculations in Dyson (1996, chapter 4), but for a good discussion of this topic, see Alexandratos (1997).

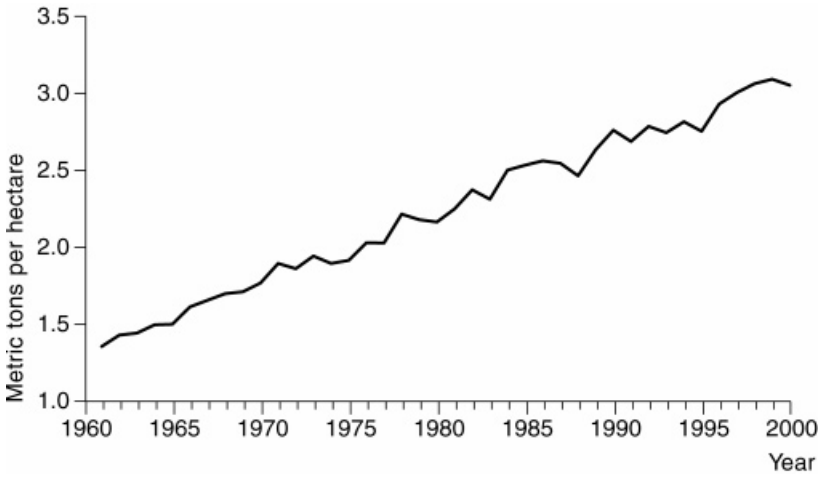

FIGURE 3. World cereal yield, 1961–2000

growth will be the key to the future expansion of the world's food supply. Indeed, yield growth will be absolutely crucial—because the only alternative way of raising food output is by increasing the *area* of harvested land. Yet, particularly in the very populous regions of Asia, there is very little new land that can be brought into cultivation. And in much of the rest of the world, as Paul Waggoner (1998, 89–90) has argued eloquently, it is only through the achievement of higher yields that land will be spared for nature.

Therefore, the trend of the world cereal yield is certainly a matter of interest. In this context Figure 3 shows that, despite some fluctuations, there is no real sign that world cereal yield growth is slowing down. Since the early 1960s the average cereal yield has increased by about 45 kg per hectare per year. In the early 1990s the annual increment was less than this, but in the late 1990s it has been greater. Notice that—and in line with Malthus's intimation—world cereal yield growth tends to be *linear* in form. If the average global yield continues to increase at the rate that applied during the 1990s as a whole (i.e., around 42 kg per hectare per year), then by the year 2025 it will reach about 4.16 metric tons per hectare. And in this context it is noteworthy that the plant physiologist Lloyd T. Evans (1998, 90) has used a simple plot of the world average cereal yield and the world's population at different points in time to draw the conclusion that "we must reach an average yield of 4 tons per hectare . . . to support a population of 8 billion." An average yield of 4.16 tons on the area that was harvested of cereals at the beginning of the 1990s (i.e., about 707 million hectares worldwide) would produce a world cereal harvest of about 2.94 billion tons—a figure that is

likely to be close to, or perhaps higher than, the total global volume of effective demand for cereals that will be produced by population growth and increased levels of per capita consumption (Dyson 1996, 1999).

We have remarked already on the strength of recent cereal yield growth in North America and for the EU's fifteen member nations. Both of these groups of producers should have no major problem in increasing their yields in the decades immediately ahead. Indeed, in all probability their main problem will continue to be one of overproduction in relation to effective demand. It was this problem that underpinned the fall in the world area harvested of cereals from about 726 million hectares in 1979–81 to only around 675 million hectares in 1998–2000. Recent cereal yield growth in Latin America has also been strong. According to FAO data, the average yield for the region rose from 2.13 to 2.80 tons per hectare between 1989–91 and 1998–2000. In both South Asia and East and Southeast Asia, cereal yields increased during the 1990s broadly in line with trends during the 1980s (Dyson 1999, 5931). In India between 1989–91 and 1998–2000, the average cereal yield rose from 1.91 to 2.30 tons per hectare, and the corresponding figures for China were 4.19 and 4.88 tons. The main areas of the world where recent cereal yield trends have been disappointing are sub-Saharan Africa and the countries of the former Soviet Union. In sub-Saharan Africa, FAO data indicate that the average yield remained roughly constant at about one ton per hectare throughout the 1990s. And in the area of the former Soviet Union the average cereal yield actually fell from 1.77 to 1.55 metric tons between 1989–91 and 1998–2000.

To a considerable extent the gains in yields that are projected to occur in most world regions during the next two or three decades are likely to happen through the wider application of knowledge and technologies that already exist. This is not to deny that agricultural research will continue to play an important role. But it should also be appreciated that future yield growth will probably not be critically dependent upon "wonder breakthroughs." In fact the basis of yield growth is remarkably complex. Many factors contribute to it, including, for example, gains in education. Developments in storage and transport should also help to improve food supplies. Raising food crop yields will not be easy in the future (but then it never has been easy to raise yields). Clearly, although they are sometimes exaggerated,[16] there are major challenges ahead, for example relating to soils and water supplies. Water, in particular, is a resource that is going to have to be used much more efficiently; and in many contexts it is a resource that will

[16] See Johnson (1999, 5919–20) for a discussion of the tendency to exaggerate the extent of cropland degradation in developing countries.

have to be *priced*. Another key driver of future yield growth in many locations (e.g., South Asia) will be the greater application of chemical fertilizers. Currently about one third of all protein in the human diet is estimated to come from the application of synthetic nitrogen fertilizers. Vaclav Smil (1997, 61) has stated that land-scarce countries with high population densities—like China, Egypt, Indonesia, and Bangladesh—already depend to a considerable extent upon nitrogen fertilizers for their very existence. And, like other aspects of the requirement to grow more food, the application of such fertilizers can have deleterious consequences for the environment, both local and global.

In the future, as in the past, in most developing world regions the bulk of the rising demand for food will be met from within each region's own production capabilities (Alexandratos 1999, 5909). Yield trends and projections suggest strongly that this will be the case. And, irrespective of the path of future international agricultural trade reforms, major countries like India and China are unlikely to become heavily dependent upon cereal imports. However, many smaller countries, for example in the Middle East and Southeast Asia, are likely to meet a rising fraction of their future cereal consumption requirements through purchases on the international market. So during the next two or three decades, the volume of the world trade in cereals is expected to rise by a multiple of two, or perhaps more.

North America will continue to be the largest cereal-exporting region, and Australia and Argentina will both continue as significant exporters as well. However, the European Union will probably remain as an additional major cereal-exporting bloc. As Nikos Alexandratos (1999, 5909) has aptly stated, the emergence of Western Europe in this role "is a structural change that is probably here to stay even under the more liberal trade policy reforms of recent years and the further ones to come." Also in this context, one should bear in mind the likely enlargement of the EU eastward to include, for example, Poland (a country with considerable agricultural potential). In the longer run it is possible to envisage that parts of the former Soviet Union—especially Ukraine, and areas of western Russia—may emerge as significant cereal exporters when their agricultural systems are eventually reformed and capitalized. So while there can always be difficulties for relatively short periods of time (as during the so-called "world food crisis" of 1972–74), in general there should be no problem in meeting the likely growth in the volume of cereal demand over the medium run. Indeed, one can predict with some confidence that this time horizon will see continuing agricultural trade wrangles between the North Americans and the Europeans. In developed regions of the world the farming sector is likely to continue to experience a trend towards larger farm sizes,

a reduction in agricultural employment, and little if any upward movement in food prices.

A final comment is required regarding sub-Saharan Africa. This region probably faces the sternest food prospects. And, of course, it is a region that faces many other problems too. Not only has past yield growth been minimal, but much of this region's future increase in food production will probably occur through an expansion of the harvested area—often with adverse consequences for the environment. The total amounts of food produced and consumed in sub-Saharan Africa are actually relatively small. Thus while the region currently contains about 11 percent of the world's population it harvests only about 4 percent of the world's cereals (an annual crop of around 75 million tons). Hence the region's total cereal output is significantly less than the fall in cereal production that occurred in the area of the FSU between 1990 and 1995. Surely sub-Saharan Africa deserves greater attention from the wider world apropos of the conditions affecting the growth of both its food demand and its food supply. The former involves increasing the availability and use of modern methods of contraception; the latter involves greater investments in appropriate agricultural research. Over the medium-term future it seems probable that many countries in this region will not manage to increase their food production in line with their demographic growth. Nor will many of them have the financial resources to purchase cereal supplies from outside. In the long run significant improvements in sub-Saharan Africa's food and agricultural situation may have to await various political and economic developments and reforms.

Conclusions and Discussion

In conclusion, it seems unlikely that there will be a major neo-Malthusian crisis resulting in severe food shortages and massive famines during the next two or three decades. In fact, in the period since the Second World War, famines caused solely by natural disasters have become relatively rare events. Most modern food crises are closely associated with conditions of warfare and broadly analogous forms of social disruption. Some of the worst—such as that in China during the Great Leap Forward, or that in North Korea more recently—have happened where, largely for political reasons, a country has been closed to the wider world. However, even if we consider famines due to *all* types of cause (natural and human) there has been a major, if uneven, decline in the volume of world famine mortality since the middle decades of the twentieth century (e.g., see Dyson 1996; Devereux 2000). This is not to say that a major famine could not occur during the medium-

term future. For example, if there were to be warfare and widespread social collapse in a large, populous country, then a big famine could happen. However, this would not be because population growth had outpaced food production.

It should be clear that the argument here has not been that progress will be so great that hunger will be banished from the globe. Indeed, the next few decades could see an *increase* in the total number of hungry people. What actually happens to this number—i.e., whether it rises or falls—will depend upon future rates of economic growth, income distribution changes, and the scale of future demographic growth. To reiterate, the world food problem is complex and difficult. It can be measured in different ways and viewed from different angles. There are no easy answers—especially to the problem that many people in the developing world are poor, uneducated, and have relatively little to offer in an increasingly integrated global marketplace. Many of these people live in environments where major rises in food and agricultural production are unlikely. This is not to deny that some progress has been made in the past, nor is it to deny that some progress can be made in the decades ahead. However, it is hard to see that alarmist neo-Malthusian pronouncements do much good.

Finally, perhaps an additional word of caution is appropriate. The several mainstream analyses of world food prospects—the conclusions of which generally chime reasonably closely with those presented here—essentially all use a mixture of projection, extrapolation, and judgment based upon the experience of recent decades. For example, and very plausibly, they see birth rates continuing to fall, and cereal yields continuing to rise. And their central shared conclusions—e.g., that the international trade in grain will probably continue to increase, and that the total number of hungry people will remain stubbornly high—should be seen in this vein too. Obviously, as Malthus implies in the quotation at the head of this piece, when considering the future there is really no other guide than past experience. However, history also shows that unexpected events *do* happen. Of course, not all surprises are bad. But a major famine resulting from a major war certainly would be. Similarly, mainstream analyses of global food prospects assume that climate change will be relatively gradual over the medium term. Even small changes in climate may have bad effects for poor farmers (although there may be winners as well as losers). However, a *sudden* change in climate would certainly disrupt global food production and lead to massive problems.

Also apropos of the world's climate, the UN's "medium" *long-range* projection suggests that the human population will stay above nine billion for most of the coming century and a half (United Nations 1999).

Inevitably this number is rather speculative, and it may well prove to be too high. However, it certainly highlights the crucial issue of world population *scale*, particularly in a context of rising levels of energy use. Thus it is one thing to conclude—as we have here—that during the next two or three decades, to adopt the words of Malthus, our *power of increasing the produce of the soil* will very probably exceed the *power of mankind to increase*. However, it is another matter to judge whether, over the longer run, a human population of nine billion (or eight, or seven, or six) will manage to live within the global environment while preserving the conditions for food and agricultural production.

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