The World Food Shortage in the Year 2020 and the Needed Agricultural Transformation in Japan

Hiroshi TSUJII

辻井　博「予測される西暦2020年の世界食糧不足と日本農業の改革の必要性」　21世紀初頭には世界は厳しい食糧不足に直面すると考えられる。この食糧不足は農産物の大輸出地帯・国であった欧米の農業政策の転換と国際農産物貿易の新しい枠組み，農業技術進歩の限界，農業生産の基盤である自然資源（水や農地）の賦存量の限界と質の劣化，潅漑投資拡大の限界，人口爆発，アジア特に中国を中心とする途上諸国の早い経済成長とそれによる食糧消費構造の変化および飼料穀物需要の爆発によって引き起こされる。本稿では先ずこれら諸要因が過去および将来にわたって世界の食糧需給にどのように作用するかを内外の文献，統計を利用して分析する。それに基づいて，これら諸要因の影響に関する前提条件を設定し，単純な外挿モデルで西暦2020年の世界の食糧需給を日本，中国，インド，アジア諸国，途上諸国，欧米，世界に関して予測し，大量の不足の発生の可能性を明らかにする。

この世界的食糧不足の予測の下，日本の穀物自給率は93年の28%から2020年には21%に下落し国民の食糧の安全保障に関する不安は増大する。日本はその農林水産業と農林水産物の貿易に対する政策によって欧州諸国に比べ，内外の環境を激しく破壊し，国内の農林水産業や農林漁村を破壊し過ぎ，コメ輸入によってアジアに集中する5億を越える飢餓人口を危機に陥れ，これら問題を引き起すという意味で農林水産物を輸入し過ぎてきた。日本は，この輸入を抑制し内外の環境破壊を削減し，国内での食糧・その他農林水産物の自給率を大幅に上昇させ，世界の飢餓人口に迷惑を掛けないという点で国内での社会的合意を形成し，自給的・循環的・低投入(LISA)的農林水産業を構築する必要があることを示す。

1. The Long-Run Causes of the Grain Shortage in the 21st Century

The world grain stock ratio (ratio of stock volume against use volume) has shown a tendency to fall since 1987 as Figure 1 shows, and the international trade prices of grains had risen during 1987 and 1996 as Figure 2 shows and have been rising in October 1997. According to the data released in August 1997 by the United States Department of Agriculture (USDA), the world grain stock ratio for all the cereals was 15.58% at the end of the crop year of 1996/97, the details of which are shown in Figure 1, such that wheat was 18.86%, rice was 14.48%, and coarse grain (grain other than rice and wheat, such as corn and barley which are mainly used for feed) was 13.89%; they are just around, or much lower than, the 17% mark which is the safety standard of the Food and Agriculture Organization (FAO) of the United Nations. These stock ratios are at the worst level since the war, except for rice, and are lower than the level during the food crisis year of 1974. Estimates for the end of the harvesting season in 1997/98 are slightly lower than the previous season except wheat and they are 15.25%, 21.42%, 14.03% and 11.75% respectively. Mr. J. A. Sharples, a specialist on the world

Fig. 1 Stock/Use Ratios of World Major Grain
At the End of Each Crop Year

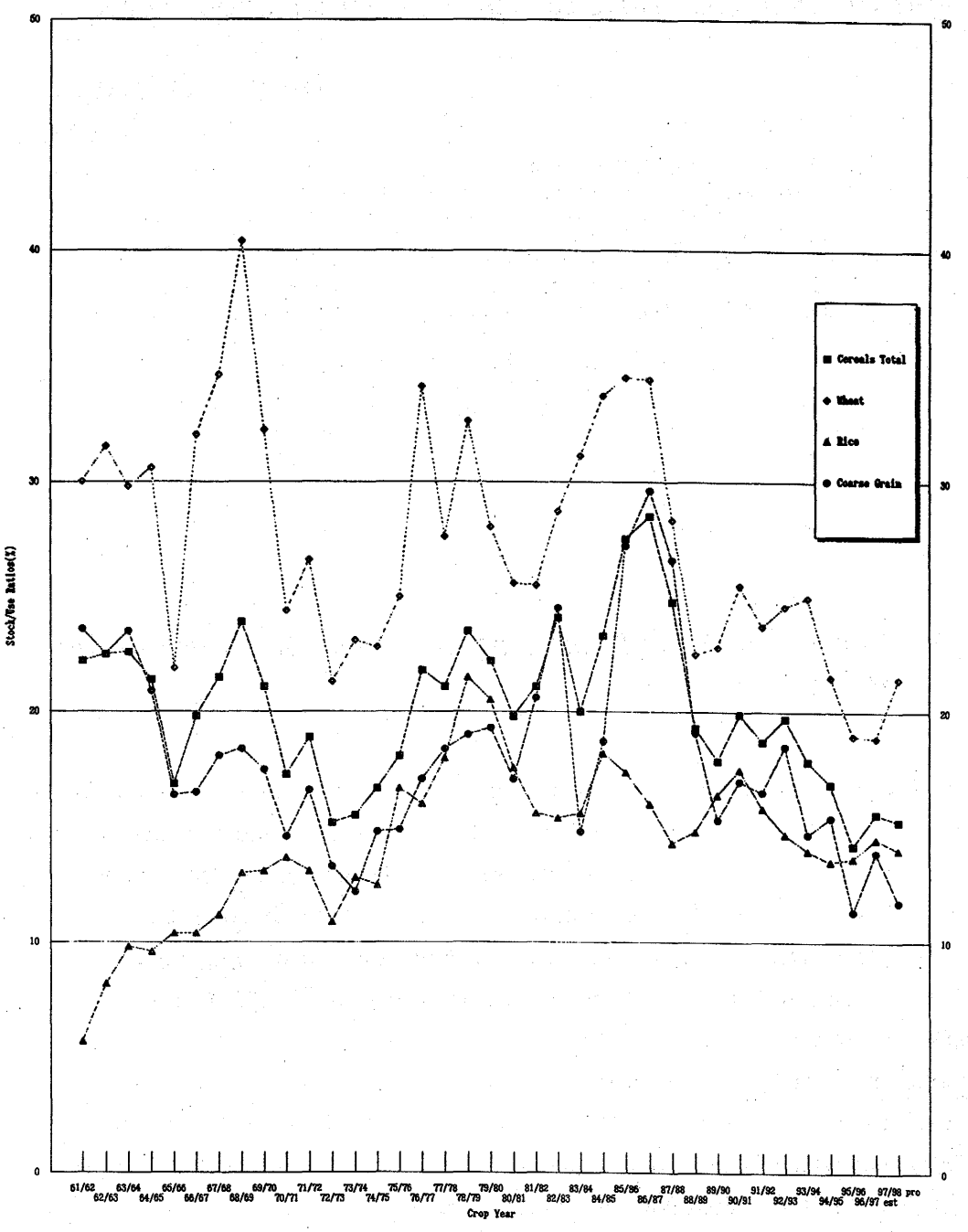
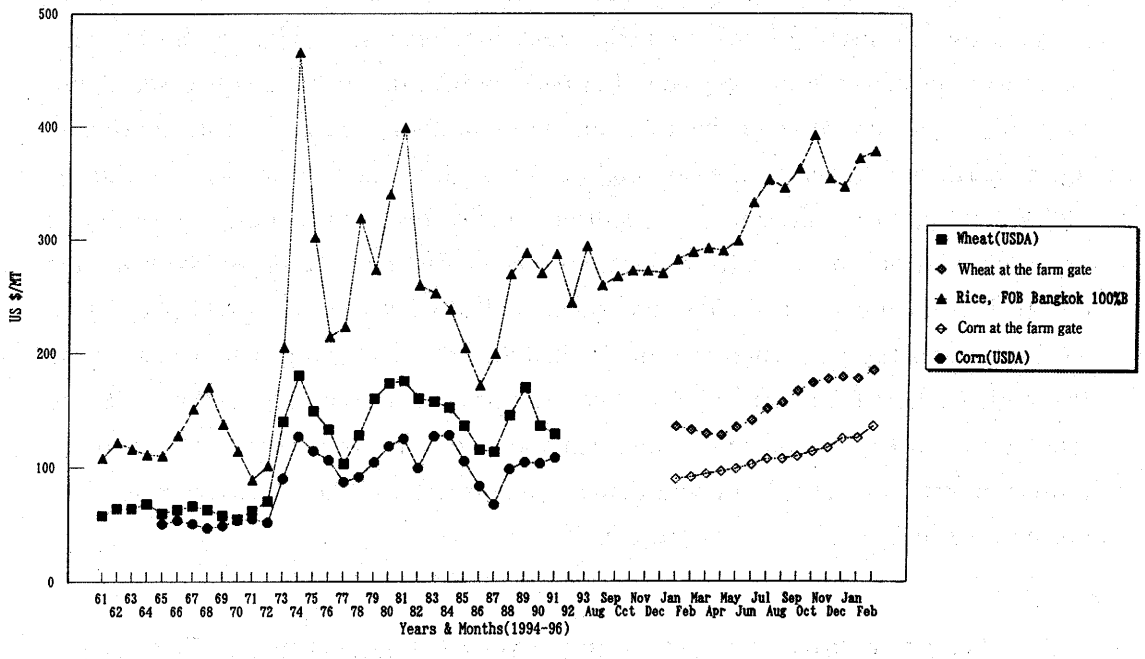


Fig. 2 International Prices of Grain
Annual Averages (19961-'94) & Monthly Prices (Aug '94-Feb '96)



grain market in the United States Department of Agriculture, mentioned in the fourth issue of *Choices* magazine in 1995 that the falling world total grain stock will reach a very low level in autumn 1996 because then 72% of the stock is the pipeline stock in the marketing channel and 27% is the national reserve stock to cover poor harvests in each country such as China and the ex-Soviet Union, etc. Especially he said that the stockpile of major grain exporting countries such as America and Canada, which have played the role of international grain reserve stock holding countries since the war, will be only 1.4% of the estimated world low grain stock. The world grain market was really near to crisis. The Chicago grain futures price and rice export price in Bangkok had been increasing since the beginning of 1995, with the price of corn reaching $5.48 per bushel on July 12th, 1996, the highest price on record, wheat reached around $5 which was a 15 year high, and the price of soybean also increased approximately by 30% since October 1995 in reaction to this situation. The Bangkok free-on-board (FOB) export price of 100% first grade rice rose to $465 per ton on September 5th, 1996, which was also a 15 year high.

Although some of this reduction in grain stock ratios and the subsequent increase in grain prices are caused by short term reasons, such as reduced produc-

tion of rice and coarse grain in the 1995 crop year in America, surplus investment funds flowing into the grain futures market caused by a general slow-down in business of high income countries and the increased price of feed grains caused by an increase in the price of American beef due to mad cow disease; but basically they are affected by the long term factors such as transformation in agricultural policy during the late eighties through to the nineties in both Europe and America, the limitation in agricultural technology improvement, scarcity in and degradation of natural resources such as soil and water, socio-economic constraints on the yield of rice and wheat and other grain, the world population explosion and the rapid increase in the demand for feed grain caused mainly by the high economic growth in Asia, most notably in China. The effects of these long term causes on food supply and demand in the world in year 2020 are investigated in terms of supply of and demand for grain, and the necessary reform of agricultural policy of Japan is presented.

2. Transformation of Agricultural Policies in Europe and America after the Last Half of the Eighties.

Since the last half of the eighties, the agricultural policies in Europe and America have changed from protectionist, surplus producing and export dumping policies to policies of reducing protection, curtailment of surpluses, correction of inter-regional differences and environmental protection. The EC earlier had achieved increased production, improving its agricultural structure and increasing the farm income level through variable import levies of the Common Agricultural Policy (CAP), export subsidies and domestic price support. It also became self-sufficient in major agricultural products within the EC region by the first half of the eighties. Until the seventies, it used to be a net importer of grains, at an average of approximately 30 million tons annually, but by 1984 it had become a net exporter, and by the subsidies of CAP, it exported more than 20 million tons annually by the end of the eighties. The excess agricultural products stock in the EC reached an enormous level, such as 1.7 million tons of butter by 1986, 620,000 tons of skimmed powdered milk and 610,000 tons of beef in 1984. The financial burden for the price support and the export subsidies for the excess agricultural products reached the unbearable level. The European Ag-

ricultural Guidance and Guarantee Fund (EAGGF), the amount of which represents the level of the price support and export assistance for the excess agricultural products of CAP become nominally 1.8 times higher in 1985 compared to 1979-81, and 1.2 times in real terms.[1] The transformation in the EC agricultural policy started with production control and decreasing the support price in 1982, and it was gradually strengthened afterward. Then it was expanded to environmental maintenance and reduction of inter-regional differences, while ensuring the objectives of improved productivity, stability of supply and farmers livelihoods, and sound pricing of CAP as stated in the Prospects of the Common Agricultural Policy (Green Paper) in 1985. A comprehensive financial reform plan (Delor package) in 1987 was also heading in this direction, and was agreed by the European Board of Directors in February 1988. The stabilizer which was to reduce the financial burden, and set aside which was intended for production reduction and environmental preservation were introduced along with the mid term financial plan which started in the same year. Finally, a significant agricultural reform in 1992 was agreed that had objectives of big reductions in the support price, farm income subsidy proportionate to arable area, set-aside requirement for farms with more than 20 hectares, protection for the medium and small scale farm managements (e. g., special assistance for the agricultural management by the youth), the preservation of the environment by the extensification policy (special action for the disadvantaged areas and environmental preservation areas). Then these reforms were subsequently merged with the agreements of the Uruguay Round Talks of 1993, whose major characteristic were tariffication of the variable import levies, minimum access import, reduction of export subsidies and decrease of domestic protection.

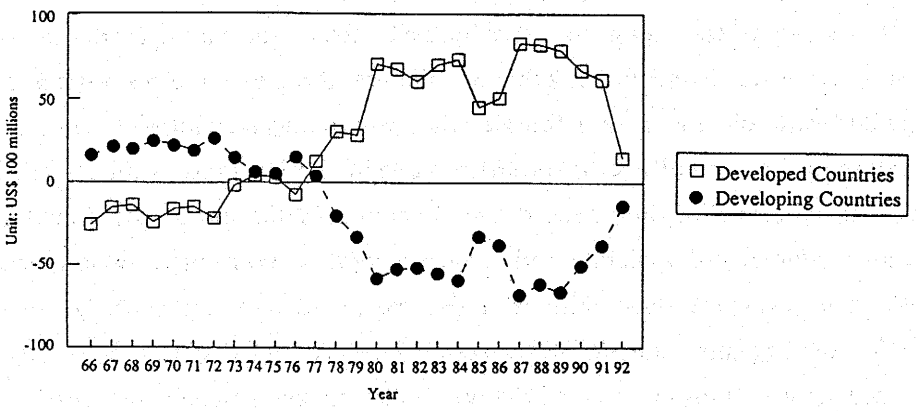
Annual grain export from America continued to increase, reflecting the strengthened U.S. agricultural protection and taking advantage of the world food crisis in 1974, from 40 million tons in the sixties to a peak of 112.7 million tons in 1981. The Federal government agricultural financial expenditure in America rapidly increased nominally by 2.2 times and by 1.7 times in real terms by 1985 from the period of 1979-81.[2] However, grain exports fell sharply during the first half of eighties, reflecting excessive domestic protectionism, a strong dollar and the rapid increase of grain exports from the EC, and the total U.S. grain stock increased significantly from 50 million tons in the mid-seventies to 200 million tons by 1986. Stocks of individual agricultural products increased also. The stock

of butter increased from 50,000 tons in 1975 to 230,000 tons in 1984, skimmed powdered milk from 200,000 to 640,000 tons, wheat from 11.8 million to 38.1 million tons, coarse grains from 15.5 million to 31.7 million tons and milled rice to 2.5 million tons in 1986 equivalent to a half the total annual domestic production volume. Financial expenditure increased rapidly to an excessive level to protect domestic agriculture and to subsidize export of the excessive stock of agricultural products. To cope with these problems the following policy measures were introduced by the 1985 Agricultural Law. They were flexibility or reductions in grains planted area for the first time by the 50/92 policy, reductions in the target price and in the farm support price (loan rate), the Conservation Reserve Program (CRP) which took a total of 18 million hectares of high erosion risk areas out of production through the grant of annual average rent of $121/hectare to the owners and new subsidy of marketing loan which decreased the grain export price to the international price level. These measures except marketing loan were production restriction policies, and these policies were further strengthened by the 1990 Agriculture Law, in such examples as the expansion of flexible planting and fixing the program yield which is the base for the calculation of deficiency payment subsidies to farmers. These measures to reduce agricultural protection, surplus and financial expenditures were finally absorbed into the agreements reached in the Uruguay Round agricultural products trade agreement in 1993.

Thus agricultural policies of Europe and America had been transformed greatly from those of high protection, surplus accumulation, and heavy export subsidy to those of lower protection, less surplus, less export subsidy and more concerns to environment and less advantaged areas from 1985 to 1993. These transformations can clearly be seen in the long term reversal in the trend of net food export volume between the developed countries (Europe and America represented the most of food export of these countries) and the developing countries in the world from the last half of the eighties as shown in Figure 3. The net export volume of food excluding fish (hereafter just called food)[4] is calculated by taking the difference between the export and import values of food for both types of countries deflated by the FAO agricultural export/import price indices respectively with 1966 as the base year. Before 1985 developed countries, who had been net importers of food during the sixties and early seventies, became net exporters from 1977, mainly through increased agricultural protection, surplus

Fig. 3 The Transformation in the North-South Food Demand and Supply Structure from the Last Half of the Eighties

—Real Net Food Export Value at the 1966 Prices—



Source : FAO Trade Yearbook

production and export dumping, and by taking advantage of the food crisis in the mid-seventies, and then they increased their net export volume rapidly by the early eighties. On the other hand, the developing countries changed from being net exporting region of food to net importers as shown in the chart, and their net import volume increased rapidly. This change is caused by the fall in the food prices in the developing countries resulting from the dumping export of surplus agricultural products by Europe and America and by the policy of taxing the agricultural sector of the developing countries themselves. The change in the world food trade pattern from the seventies to 1985, was unfair because the developed rich industrialized countries dumped their surplus food to suppress food production and agricultural income of the poor agricultural developing countries and their farmers, and the farmers in the developing countries were exploited by their governments. This change is also undesirable from the view point of comparative advantage because the industrialized developed countries export or dump food to the agricultural developing countries.

The transformation of the agricultural policies in European and America started in the late eighties, was not done in order to correct this unfairness and to ensure the North and South comparative advantage, but to reduce the excess financial burden of the above mentioned agricultural protection, to preserve the environment and to correct inter regional differences in the EC and America. Net food exports from developed countries decreased considerably in 1985, and

showed a rapid reduction in the nineties. The developed countries' agricultural production index of the FAO has fallen considerably from 1986 to 1992.

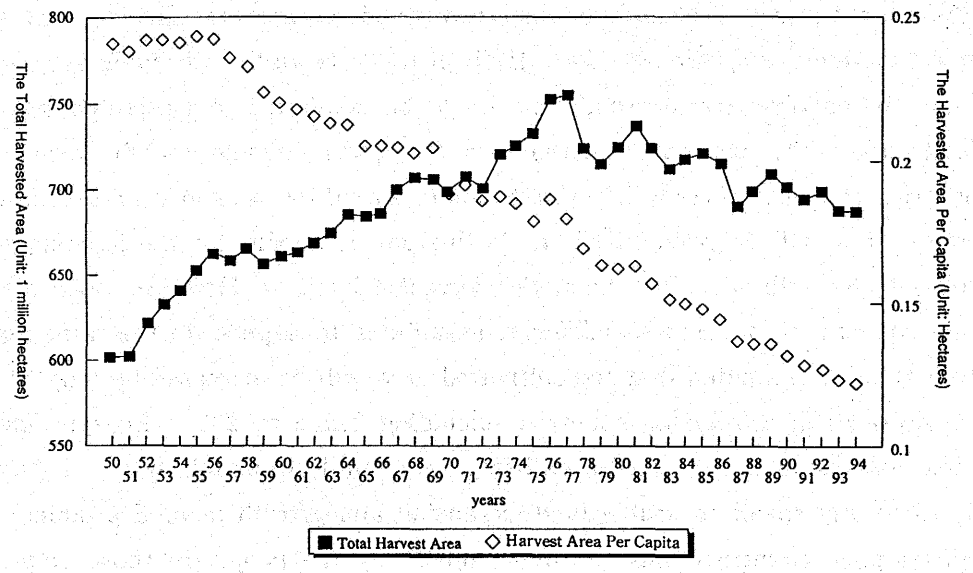
According to the FAO, food production per person in Europe showed a declining trend from the peak in 1984 to 1992. Also, the same tendency can be noticed in America from its peak in 1981. These changes have been enhanced by the agricultural reforms within the EC, the American Agricultural Laws in 1985 and 1990, and the agricultural trade agreement of the Uruguay Round Talks.

The transformation has caused the continued reduction in the world grains stock as previously described, and a corresponding continuous grain price increase. This transformation will be maintained into the 21st century under the World Trade Organization (WTO) system. The decoupled direct farm payment, liberalized grain planting and abolition of the target price in the Agricultural Law of 1996 in America will not force the Federal government to hold large agricultural surplus. The continuous reduction of agricultural protection within the EU will be pursued. The state of low global grain stocks and high and unstable grain prices will be maintained. As a result the unfairness before 1985 mentioned above will be reduced, and the comparative advantage will be restored to some extent. However, the grain price will rise and will be de-stabilized as the international grain stocks of Europe and America will run low, and the world 1.1 billion poor and the 800 million starving will face serious crisis.

3. Supply Factors

Long term supply factors which regulate grain production are natural resources such as land, water and irrigation, and agricultural technology. The annual growth rates of global cultivated area for grains have been falling last three decades according to the FAO data. The growth rate for the sixties was 0.33%, 0.28% for the seventies and 0.18% for the eighties. As shown in Figure 4, the global per capita grain harvested area has fallen from 0.24 hectares in 1950 to 0.12 hectares in 1994 as a result of the population explosion and the economic limit in the expansion of cultivated area during this period. The total grain harvest area in the world increased to a peak of 760 million hectares in 1977 as shown in the same Figure, but it had since fallen to 690 million hectares in 1994. According to the data from the USDA, grain harvest area in China has been fall-

Fig. 4 The World Total Harvested Area for Grains and the Harvested Area Per Capita



Note: Data mainly from FAO and from USDA for some data.

ing since reaching a post-war peak of 98 million hectares in 1976, and had reduced by 7% to 91 million hectares by 1992. Although the grain harvest area in India increased by 14 million hectares from 1961 to its peak of 106.6 million in 1983, it had fallen by 6.26 million hectares by 1992, and this trend will continue in the future.

According to the FAO data for 1989, the total cultivated area in the world is approximately 1,500 million hectares, about 800 million hectares of which are in developing countries. Also, the total area of pasture and forest in the world is 7,400 million hectares, 42% of which is in developing countries. How much of this pasture and forest area in the developing countries can be turned into arable land for grain production is the most critical issue in order to cope with the food problem there. This is because more supply of agricultural land in developing countries is needed in order to cope with the rapid economic growth and population explosion that has been concentrated there and will be so as we head towards the 21st century. An FAO report estimated the potentially cultivable area for at least one of the 21 important crops in 92 developing countries, excluding China, based on the data for soil condition, topography, temperature and water supply.[5] It was more than 1,800 million hectares, more than twice as much as the current cultivated area of 760 million hectares in the developing countries.

Though most of this potentially cultivable area is in South America (48%) and Sub-Saharan Africa (44%). Other institutions and researchers came up with similar estimation during the seventies. If all of the potentially cultivable area which is mostly pasture and forested land could be converted to cultivated areas, it could cover the necessary increase in the grain demand for the developing countries from the current 1.1 billion tons to 2.3 billion tons in year 2020 (my estimates that will be presented later in this paper) needed for the population increase to 6.6 billion in 2020 from the current 4.3 billion. However, such a large scale conversion of pasture and forest is unlikely to happen. In the same report, the FAO also estimated that the cultivated area will be increased by only 93 million hectares in developing countries excluding China by 2010.[6] Reasons for the actual expansion in cultivated area being very small are as follows:

(1) Generally speaking arable land expansion and growth in food production in developing countries must be done mostly by the people in those countries. Those people are mostly farmers, and when they increase food production, then they can increase their agricultural income, and consequently can consume the increased food production. I call this relation the regional food production and consumption inter-dependence. If this inter-dependence can not maintained, and food production is increased in other developing or developed countries, and the increased food production is to be supplied to the developing countries where food production is not increased, but there is not enough demand for food in the latter countries because there is no increase in agricultural income to purchase the supply. The inter-dependence means that in developing agricultural countries it is the size of agricultural population and not size of potential arable land basically determines size of cultivated area. The developing countries in South America and Sub-Saharan Africa have a little more than 10% each of the total population of all the developing countries. Thus vast cultivable land in these areas will not be reclaimed by large amount.

(2) Due to fast economic growth in developing countries, pastures and forests (and even cultivated areas themselves) have been and will be converted to houses, roads and factory sites rather than being converted to farming land.

(3) Demand for grass, livestock products which rely on pasture, and forestry products will increase along with economic growth in developing countries.

(4) Opposition to losing such non-economic value as beautiful scenery of forest

and pasture and need for soil conservation, water conservation, and conservation of genetic resources.

(5) Excessive public investment cost for reclaiming the potentially cultivable area in South America and Sub-Saharian Africa.[7]

There has been rapid economic growth and also a swift conversion of farm land to non-agricultural uses in Asia. In Japan the Agricultural Land Law has been an important institution to preserve farm land. In Asia i.e. the world growth center, superior quality farm land has been rapidly converted to factories, houses, roads and non-cultivated land, especially in China, Thailand, the Philippines, and Indonesia (Java), etc. According to my own observations during the last twenty years, a considerable part of one million hectares of good rice producing land in Menam Chao Phraya Delta surrounding Bangkok, Thailand has been converted to non-agricultural land or unused land. The global shortage in cultivated area will increase as population explosion and economic growth will continue until early 21st century.

Soil quality has been deteriorating throughout the world. According to one research, 15% (2 billion hectares) of the total land of 13 billion hectares on the globe has been degraded.[8] Of that total, it is said that 16% (300 million hectares) is severely degraded. In the intensive research interviews which I undertook in 1993 and 1994 with about thirty farmers scattered over semi-arid North-Eastern Thailand, every farmer without exception said that they had experienced a decrease in the yield of rice and cassava within last twenty years, and identified the decrease in soil fertility as the cause.

Although the growth rate of global irrigated area has been above 2% annually in the sixties and seventies, it fell to just above 1% in the eighties.[9] The irrigated area per person reversed since 1978 from the previous increasing trend, and decreased 6% by 1991. According to the FAO, this tendency in the irrigated area is a serious limitation for food supply for more than a half of the increase in the global food production resulted from the increase in irrigated area from the mid-sixties to the mid-eighties. This slowdown in the growth of the global irrigated area is governed by economic, managerial and environmental reasons.[10] Economic factors are firstly, the declining trend in real international grain price after the Second World War, and secondly, the increase in the cost for building large scale surface irrigation systems within the past decades.[11] The cost efficiency of small scale irrigation systems such as Danbos in Sahel and tube-wells

in India are important to note. Managerial factors are such that more than half the irrigation facilities in the developing countries currently need to be repaired and also these facilities are operated far below their designed capacity, so much water is wasted, and water logging and soil salinization are not appropriately managed. The environmental factors are soil salinization, which is said to occur in 10% of global irrigated areas, human diseases related to irrigation water, environmental damage caused by dams, and the external values derived from aquatic ecological environment.

As agriculture uses two thirds of the world's fresh water supply, there are strong restrictions on agricultural water resource. Fresh water resource is being diverted to industrial and household uses as the economy grows in all the countries of the world. Exhausting underground water resource by over-utilization for agricultural purposes has been occurring in America, Northern China and India.[12] Irrigation investment has stagnated as previously mentioned. During my survey in America in the late eighties, I have personally witnessed the water shortage at that time and in the long run in California due to the difficulties in building irrigation dams because of the environment protection movements, and destructive reduction of underground water level due to excessive pumping-out for rice crops in Texas.

The needed future increase in the world grain supply must rely on yield increase under the restrictions on cultivated land, irrigated areas and water. The green revolution increased considerably the yield of wheat and rice from 1961 to 1985 as shown in Table 1. The grain yield has been increasing annually by 2.7% for wheat and 2.2% for rice over the last thirty years. The yield for maize, barley and all cereals has also increased considerably. However, limitation can be seen recently on the growth rate of the yield. The growth rates in the yield of these grain and of all the cereals have declined rapidly between 61 and 96 as

Table 1 Recent Stagnation in the Annual Growth Rate in the Yield of Major Cerials in the World

Unit: %

	All Cerials	Paddy Rice	Wheat	Maize	Barley
61/70	0.0302	0.0272	0.0361	0.0217	0.0346
70/85	0.0241	0.0213	0.0250	0.0312	0.0126
85/96	0.0120	0.0122	0.0144	0.0090	0.0063

Date source: FAO Production Yearbook, via FTP.

shown in Table 1.

Although, the (theoretical) potential yield of new varieties of rice and wheat is clearly greater compared to the ordinary varieties, it is sometimes lower in experimental fields and farmers' fields.[13] Yield of new high-yielding rice varieties in the experiments at the International Rice Research Institute (IRRI), national rice research centers and farmers' fields in Asian countries, have recently been static or reducing.[14] There is a problem of excessive use of paddy fields as symbolized by triple rice harvests per year in Asia. The stagnation in yield is also seen in the double cropping of rice and wheat, and also a fall in factor productivity of wheat is seen.[15]

Let's see the movement of grain yield and production in China which is a very significant agricultural country on the globe. According to the FAO data, grain yield has increased substantially after the war from 1.9 tons per hectare in 1961 to 4.5 tons in 1994. Although grain yield has undoubtedly increased, I thought the yield in 1994 was too high. Surprisingly, it became clear from a recent investigation of the Chinese Science Academy that the statistics of cultivated area in China were 40% less than the actual amount. If we re-calculate the yield in 1994 with this actual area, it is about 3.2 tons. Even with the revised yield, it is at the same level as the average grain yield in Japan, America and Europe in the same year, which is very high. Water shortage is a serious short-term and long-term problem in China. The prices of agricultural inputs such as chemical fertilizers have started to increase rapidly from the early nineties, and will remain at high level in the future. Agricultural research investment has stagnated.[16] Consequently a continuous increase in the crops yield will be difficult in the long term. In my recent survey in China, superior farm land had been rapidly converted to nonagricultural uses because of the extremely rapid economic growth until early nineties. The harvested area of grain had been reduced at an annual rate of 0.462% from the post war peak in 1976 to 1992. Grain production (including soybean) in China had increased at an annual rate of 3.42% from 130 million tons in 1950 to a mid-term peak of 407 million tons in 1984, and although it reached an historical record of 466 million tons in 1995, it had only increased at a rate of 1.24% annually from 1984 to 1995. The Chinese government raised the buying prices of the grain under the quota system from the farmers by 88% in July 1994, and by 20% in 1996 as well. However, these were still a long way off the free market grain prices. It is reported that many farmers stopped

rice and grain production because of the government low buying prices.[17]

Various factors can be considered for the recent rapid declines in the growth rates of global average grain yield and grain production. The grain yield increase in the green revolution was made possible mainly by the increased use of fertilizers. The world total fertilizer use started to fall from the late eighties, and it has continued to fall until the mid-nineties, and it is expected to be stabilized during the whole nineties.[18] The effectiveness of chemical fertilizers in increasing the grain yield has decreased globally, and it was only one fifth as effective in the period 1984-89 as it was in 1950-84.[19] This may reflects the exhaustion of our technical knowledge accumulated in the grain varieties. The global stock of agricultural technical knowledge, which in the past had been accumulated rapidly by high research investment and had resulted in the green revolution, has recently been exhausted because of the decline in the research investment.[20] Investment for agricultural/rice research in Asia has been stagnated along with the decreasing trend in the global prices of rice and other grain in real terms since the eighties.[21] Also yields of rice and wheat have recently reached a plateau and it is feared that they are near some limits for rice and wheat.[22] Global shortage in agricultural water resource and deterioration of soil fertility has worsened as mentioned previously. The significant reduction in the grain planted area and the growth rates of grain yield thus are brought about. Consequently they caused stagnation or reduction in grain supplies, and the continuous reduction in the global grain stock ratio since the mid eighties.

What will be the global grain yield towards the 21st century? Although there are many different opinions, I believe that the agricultural technology used in the green revolution has a serious problem regarding its long term sustainability, as it must use substantial amounts of chemical materials, and continually develop new varieties to cope with diseases and harmful insects which quickly develop resistance to the latest agricultural chemicals.[23] However, currently there is no other way except using this technology for a while to cope with the fast increase in the demand for food during the peak period of population explosion in the developing countries until year 2020. So we should for the time being modify the green revolution technology to be consistent with sustainable agricultural supply and to minimize environment destruction until new appropriate technology is established.

Wheat, barley, sorghum and millets have larger area where yield improve-

ment in difficult comparing with rice and maize under the current agricultural technological conditions. Thus raising yield of the former grain will be more difficult.[24] However, some are of the opinion that the significant differences that exist in the grain yield among various countries or regions in the world show the possibility of adopting existing technology and increasing yield through increased use of chemical fertilizer, and at the same time decreasing the environmental damage and soil deterioration, especially in developing countries.[25] The difference in the yield, however, shows not the difference in the potentiality in the existing technology, but in the restrictions of the natural conditions such as soil and climate on the yield in most cases as is clearly seen in the big difference between the yield of wheat in Western Europe and North America. As previously described, the growth rate of grain yield decreased significantly after last half of the eighties, and yield of new high-yielding rice varieties has been stagnating or decreasing in Asia. The harvested area of rice, 90% of its production and consumption are concentrated in Asia, has been decreasing as well. A 3% annual increase in rice yield will be needed to cope with the peak of the population explosion until year 2020.[26] Although until now, the potential yield of various crops has been raised annually by 1-2% through the efforts of genetic research,[27] a 3% annual increase in rice yield in the long term is very difficult.

How are such new technologies as bio-technology and hybrid varieties appraised for increasing grain yield? Since the appearance of hybrids corn in America in the thirties, the F1 vigor has been considered the break-through technology which would be the best means of increasing yields. But those views are too optimistic. Hybrid rice varieties in the world have been planted principally in China (55% of the country's rice harvested area in 1992), because the high cost of hybrid seed production has been mitigated by cheap labor costs and the government subsidies, and it is said that the rice yield has increased by 20%. Although the efforts have been made for the last twenty five years, hybrid wheat seeds have not been successful due to the prohibitively high cost of seed production.[28] Although a significant increase in crop yield has been expected by using bio-technology based on gene transformation and gene mapping, virtually no useful result considerably increasing crop yield has been achieved so far. Many researchers now consider that it takes several decades to extend new seeds developed by bio-technology among the majority of the farmers in the developing countries. Bio-technology is considered as an important means for genetic research, and it

is recognized to bring graduate increase rather than a brake through in yield.[29] IRRI in the Philippines intends to increase yield by 30% through extending "the super rice" using bio-technology which has the plant type with 90 cm height of four or five short and strong stalks with big ears and eliminating stalks with no ears.[30] However, it is said that this has not been achieved according to Professor T. Horie of Kyoto University who is knowlegeable about the results of experiments with this rice in Japan.

4. Demand Factors

According to the estimates of the United Nations, population explosion which has occurred mainly in the developing countries after the war, will maintain the peak level during the period from 1990 to 2020. Population increases annually from 80 million to 90 million during this period and the world population will reach to 8050 million by 2020 from 5300 million in 1990. The population in the developing countries will increase at the annual rate of 1.7% from 4080 million to 6660 million during the same period. Population in Asia will increase at the annual rate of 1.64% from 2900 million to 4500 million. The world population will double to 10,000 million by 2050. Grain (rice, wheat, barley, rye, corn, oats, sorghum and millets) will be the main source of the necessary calorie intake for the exploding global population and will be providing most of the calorie intake by the people in the developing countries which is 80% of the world total population in early 21st century.[31] The grain supply must rapidly increase during the period from 1990 to 2020 if it is to cope with the future explosion in the demand for grains caused by the population explosion and the fast economic growth in the developing countries, especially Asia.

Grain demand increases because of the increase in income as well as the population explosion. When per capita income increases in the developing countries, the immediate result is an increase in grain demand as food. An increase in the importance of animal protein in food consumption pattern as the developing countries grow, leads to the fast increase in the demand for feed grain for the animals. According to World Bank statistics,[32] the per capita GNP in Asian developing countries has grown significantly, at annual rates of 3.0% to 6.4% during 1980 and 1993, compared to other developing countries as a whole

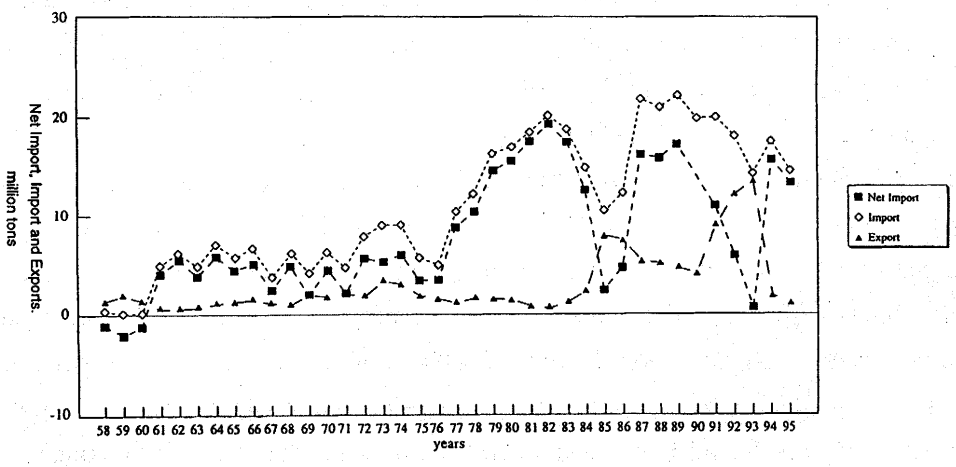
who has experienced negative growth during the same period. The average per capita GNP growth throughout all developing countries was approximately 1% per year during the same period. The total GNP has grown at around 3.5% per year. This rapid per capita income increase, especially in Asia, brought significant increase in the demand for grain which is the staple diet of the people in the developing countries, and also rapid increase in the demand for animal protein in Asia, especially in China, resulting in explosive increase in the demand for feed grain.

Let's now investigate the actual situation for the rapid increase in grain demand within China. China has 22% of the world total population in 1990, and thus she has a significant influence to future food demand. According to the UN estimates, although the Chinese population growth rate has been low (an annual rate of 0.9%) compared to the other developing countries due to "the One Child Only Policy" it has increased from 680 million to 1.2 billion during the period 1958-92, and will continue to increase to 1.5 billion by 2020. This rapid population increase will cause a rapid increase in her grain need. The economic reform which allows free decision by individual agricultural managements brought a rapid increase in grain yield and production in China in earlier years. The grain supply per person increased considerably from 230kg in 1961 to 354kg in 1995. However, it has remained static since 1985 due to the fast population growth, reduction of cultivated area and the slowdown in the increase rate of grain production as previously mentioned. Although the five year moving average of annual increase rates of grain yield had been increasing at an annual rate of over 5% during the period 1980-84, it fell to between 0.3%-3% afterward until 1992. This trend is likely to continue in the future.

The per capita GNP in China has seen very high growth rate of 8.2% per year during 1980-93, and explosive growth rate of around 10% from 1992-95. This high economic growth in China will be maintained in the future as China has planned her economic growth rate at 7-8% until 2010 at the People's National Congress on March 5th, 1996. This recent rapid income increase brought a rapid increase in demand for meat, mainly pork which is the most popular meat among Chinese, at an annual rate of 10%. One kilogram of pork production needs 4 kilograms of feed grain. The grain prices have rapidly risen through the explosion in the demand for feed grain. Corn price doubled within one year in 1995. The domestic free market rice price increased 3.2 times between January

1993 to June 1995 and it had became more expensive than the export price of the low grade 35% Thai rice which is almost equivalent to the domestically available rice in China from May 1994.[33] The Peking government prohibited the export of corn in November 1994 and soybean from April 1995 to ease the domestic shortage. Grain exports from China (including soybean) fell to almost nil in 1994 and 1995 as shown in Figure 5, and the net imports rose to 15 million tons annually. Actually, the import of a large net volume of grain into China is not a recent phenomena, but it has been 10-20 million tons annually since 1977, except in 1985, 86, 92 and 93 according to the FAO data as shown in the same Figure. There is a report that China banned corn export again in late 1997. According to a recent publication of the USDA[34], the Peking government was forced to consider the long-term demand and supply balance of food in China by foreign and domestic reasons in 1994 and 95 and conducted researches within some ministries and universities. Based on the research result, the government decided to change its food policy from long-held food self-sufficiency policy to 88-95% self-sufficiency policy. China consumes 112 million tons of wheat, 109 million tons of corn and 129 million tons of rice in 1995. An enormous amount of grain totaling 42 million tons annually (including 15.5 million tons of white rice) needs to be imported if the self-sufficiency rate is only 88%. Since the world trade markets in wheat and corn are thick meaning the total trading volume is large compared to the global total production, and the markets can manage the large import by

Fig. 5 The Post-War Volumes of Grains Trade in China
— Net Import, Import and Export —



Note: Data mainly from FAO. Some incidental USDA data for recent years.

China. But catastrophic increase in the world rice trade price and confusion can be expected for the world rice trade market is thin meaning only 4% (15 million tons) of the world total production (white rice) is traded.

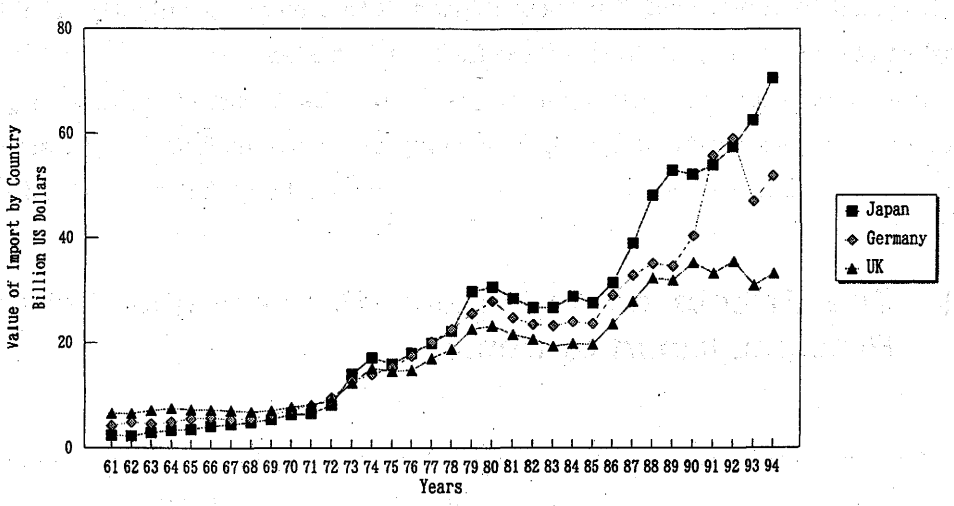
It can be said that the rapid increase that has occurred from the eighties until now in grain demand by the developing countries, especially by China and other Asian countries, has had the effect of reducing the global grain stock ratio.

5. The Effects of Agricultural, Forestry and Fishery Products Import by Japan.

According to FAO statistics, Japan is the biggest importer of agricultural, forestry and fishery products in the world. Japan imported US$70.6 billion worth of these products in 1994. Germany imported US$51.9 billion, France US$33.2 billion and Great Britain US$33.1 billion in the same year. Japan has behaved very differently compared to these European countries regarding the import of agricultural, forestry and fishery products. The amount of the import by Japan was 5.6% of the total world trade value of these products in 1961, but had nearly doubled to 9.4% in 1994, whereas the same shares for France and Germany have not changed much and they have been around 6% and 10% respectively over the same period, and it for the Great Britain had reduced from 15% to 6%. The import value of these products in Japan increased thirty-fold from US$2.3 billion to US$70.6 billion from 1961 to 1994 as shown in Figure 6, whereas it for Germany increased twelve-fold from US$4.2 billion to US$51.9 billion. Japan has developed its economy by emphasizing industrial production and export more in contrast to the European countries, and as a result she has neglected or depressed the domestic agricultural, forestry and fishery industries by increasing greatly the import of these products. I think Japan import too much agricultural, forestry and fishery products because these import destroys too much domestic agriculture, forestry and fishery industries, agricultural and fishing villages and external values attached to them, and destroys environment too much because of nitrogen and potassium discharged to the environment after their consumption.

Prawn imports for example by Japan have been mainly from Asian countries, and in 1962 it was only 3,642 tons with a value of 2.2 billion yen, which was 46% of the total import value of fishery products, but by 1991 it had risen to

Fig. 6 Agricultural, Fishery and Forestry Products
— Value of Import by Country —

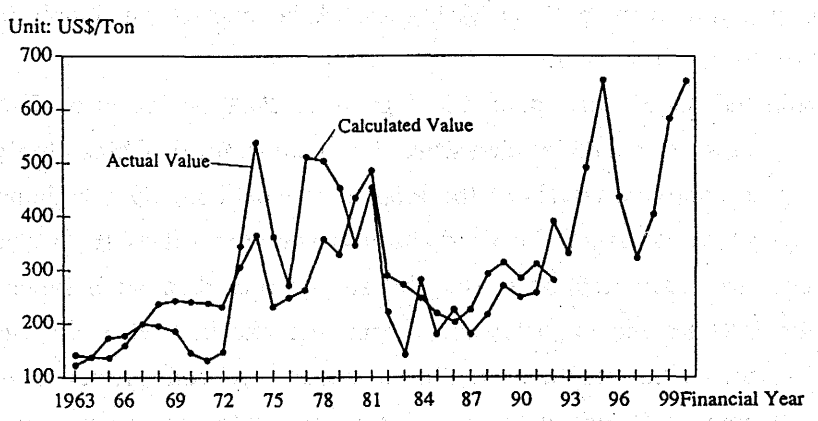


310,000 tons with a value of 412.9 billion yen, which represented 24.5% of the total import value of fishery products. The import volume of prawns increased 85 times during this period. Mangrove forest on the Thai and Indonesian coasts have widely been destroyed and the coastal area has been substantially polluted by prawn farming for export to Japan. In another example, the import value of wood to Japan was US$930 million in 1967, and it rose to US$7.47 billion in 1990. Most of these were imported from the tropics (27% of the total import value of wood came from Malaysia and Indonesia in 1990) and it caused the destruction of tropical forest. Japan import too much of agricultural, fishery and forestry products secondly because it destroys environment and forest too much abroad.

When Japan announced the official import of 2.5 million tons of white rice in September 1993 during the Heisei rice crisis, the rice trade price at the world rice trade market doubled within four months in Thailand and America, and the retail and farm rice prices in Thailand and Indonesia increased between 7-30% within 4 months.[35] Japan agreed to increase its import quota of rice from 4% of her consumption in 1995 to 8% in year 2000 in the Uruguay Round agricultural products trade talks. The estimated effect on the international rice trade price of the emergency imports of rice after the Heisei rice crisis and subsequent rice imports under the agricultural agreement are estimated by the autoregression model and shown in Figure 7. Although the price fluctuates between 1993 and 2000, the estimated average rice trade price is about double of the price level a-

Fig. 7 The Estimated Future Effects of the Japan's Emergency Imports and Minimum Access Imports of Rice to the International Rice Price

—by an Auto-Regression Model for 1993-2000—



Note: Volumes of rice import into Japan is assumed to be two million tons in 1994, one million tons in 1995, and minimum access imports for 1996 - 2000.

Source: The actual value is the BTO's quoted export price of 5% rice in Thailand.

round 1990. Consequently, the rice retail price in Asian countries will increase considerably. This will cause a crisis for the poverty stricken people (700 million in Asia out of the world's total of 1.1 billion) and for starving people (523 million in Asia out of a world's total of 839 million) in Asia as many of them eat rice as their staple food. The Japanese import of large amount of rice at any cost (Price elasticity of the Japan's import demand is small.), will cause substantial increase in the instability in the world rice trade market price. For most of Asian people it is very important to live with the situation where stable and cheap rice price is assured. Japan should refrain from importing rice. Self-sufficiency in rice within Japan is important to the stability of rice price and supply in Asia, as well as in Japan.

6. Prospects of World Grain Supply and Demand for Year 2020, and the Needed Reforms in the Japanese Agricultural, Forestry and Fishery System.

As seen in the above analysis the world grain stock will be maintained at very low levels in the long term as we head towards the 21st century, and the

grain prices will increase, because of the transformation of the European and American agricultural policies after the late eighties, the restrictions on natural resources and agricultural technology, and rapid increase in the need for feed and food grain, principally in China and Asia, due to the population explosion and high economic growth.

Projected supply and demand of grain in 2020 is shown in Table 2 for the world, groups of countries classified by income level, China, India and Japan based on the above analysis of the long term world supply and demand of grain. As regards the demand, the production conversion ratios from grains to meat and eggs are estimated based on the supply and demand balance data of the FAO for 1984-86 and expected long term increase in feed grain use in the livestock sector. The increase in the demand for feed grains is estimated by projected population growth rate, GDP growth rate and income elasticity of demand for meat and eggs. Medium estimates of the UN are used for the population and population growth rate. The FAO statistics were used to determine demand for meat, eggs and grains in 1993. As regards the supply, the growth rates of grains production, listed in the same table reflect the recent decline in the growth rates of grain production mentioned above.

There are two ways for a long term forecast of grain supply and demand. One is forecasting demand and supply independently such as the way used by me here and Lester Brown, and the other method incorporates the effect of the difference between supply and demand on the product price in the forecasting method that is used by the World Bank, the FAO, IFPRI and the Japanese Ministry of Agriculture, Forestry and Fishery.[36] Brown, the Ministry of Agriculture, Forestry and Fishery and I forecast that there would be a significant global grain shortfall in 2020 and/or 2030 and the prices of grain will rise, and others forecast that the world grain prices will decrease in early 21st century. The reasons for the totally different forecasts are basically differences in the assumptions for the projections, and thus critical evaluation of the assumptions is very important. I judge the assumptions made by the World Bank, the FAO and IFPRI are too optimistic about future cultivated land and the improvement of agricultural technology and against the recent reality.

According to my projection, there will be an enormous grain shortfall of 320 million tons in developing Asian countries in 2020 as shown in Table 2. The details are 170 million tons in China, 15 million tons in India and 417 million tons

Table 2 Projection of World Food Supply and Demand for year 2020 (For Edible Grains, Feed Grains, Meat and Eggs)

Demand Projection	1993			2020	
	Population (millions)	Consumption of Meat and Eggs Per Capita (kg)	Total Grain Demand (million tons)	Consumption of Meat and Eggs Per Capita (kg)	Total Grain Demand (million tons)
World Total	5522	39.50	1830	58.4	3269
Low and Medium Income Countries	4289	23.90	1072	58.4	2342
Developing Countries in Asia	3058	20.70	730	54.1	1473
China	1185	34.50	366	91.3	777
India	885	3.96	173	6.4	298
High Income Countries[a]	1228	93.10	767	100.0	927
Japan	124	47.80	40	52.8	42

Premises for the Projection of Supply and Demand

1993-2020				
Annual Increase Rates (%)				
Population	Consumption of Meat and Eggs Per Capita (kg)	GDP	Income Elasticity of Demand for Meat and Eggs	Estimated Conversion Rations (grains/meat and eggs, amended by the FAO data) (%)
0.0141	0.01458	0.034	0.68	3.00
0.0164	0.03354	0.06	0.70	2.40
0.0147	0.03628	0.06	0.35	1.80
0.0089	0.03667	0.07	0.60	3.00
0.0152	0.01794	0.06	0.40	2.00
0.0045	0.00262	0.022	0.15	5.88
0.0014	0.00373	0.02	0.20	3.50

Demand Projection	1993	2020		1993-2020
	Grains Production (million tons)	Grains Production (million tons)	Excess Grain Demand (million tons)	Annual Increasse Rates of Grain Production
World Total	1804	2852	417	0.0171
Low and Medium Income Countries	930	1752	590	0.0237
Developing Countries in Asia	675	1153	320	0.0200
China	340	610	167	0.0152
India	167	283	15	0.0120
High Income Countries[a]	870	1100	-172	0.0087
Japan	11	9	33	-0.0081

Note: (a) United States of America, Ex-Soviet Union, West and East Europe, Japan and Oceania.

throughout the world. Although the high income countries export 172 million tons, that is far below the world total projected deficit in year 2020. This shortfall is significant, especially when one considers that the total world grain trade volume was 230 million tons in 1993. The reasons for such a significant grain shortfall are that (1) the population explosion and high economic growth in developing countries, principally in China and Asia, will bring about a fast increase in consumption of animal protein, which will lead to an explosive increase in demand for feed grain, (2) the increase in grain supply will be restricted by limitations in natural resources and in the improvement of agricultural technology in the developing countries and (3) maintenance of the agricultural policy transformation in Europe and America started in 1985 into the 21st. century. The projection of a significant future shortfall by Brown is also for the similar reasons.

The estimation of significant grain shortfall by Brown and me will bring about a rise in the prices of grain in the world trade market. According to my forecast, assuming the long term price elasticity of the world grain supply and demand to be 0.15 (ratios between rates of change in supply and demand against the price change rate), the international grain trade price will increase by 50% compared to its 1993 level by 2020. This increase in the grain trade price will lead to considerable increase in the domestic price of rice and other grain and will cause significant difficulties to the huge poor in the developing countries, who now numbers more than 1.1 billion, and will likely be large in year 2020.

A significant global shortfall of grain is forecast for year 2020. Japan will be an important player in the long run world food demand and supply situation. Large and continuous Japanese rice import will raise and de-stabilize the rice price considerably throughout Asia which will result in the crisis for the huge Asian poor. The Japanese self-sufficiency ratio for grain is forecast to decrease from 28% in 1993 to 21% in 2020 as shown in Table 2 if the current Japanese agricultural and economic policy is maintained. This will increase Japanese sense of food insecurity very much.

The import of agricultural, forestry and fishery products by Japan increased after the war much faster than European countries and it caused serious euphorization problems in inland and sea waters in Japan and also caused severe environmental destruction abroad as symbolized by Japanese import of shrimp and tropical timber and wood. I think Japan imports too much agricultural, for-

estry and fishery products as it causes serious environmental problems in Japan as well as in the developing countries, the crisis to the huge poor in Asian developing countries in the case of rice import, and serious increase in the sense of food insecurity and loss of external values of the primary sectors by the Japanese if we will continue the speed of these products import and will destroy our primary sectors. We should reform greatly and appropriately Japan's agricultural, forestry and fishery policy and their system emphasizing more domestic production of the agricultural, forestry and fishery products, including rice, with sustainable technology which will lead us to higher self-sufficiency ratio of these products, to lower domestic and foreign environmental destruction, to the maintenance of external values of the primary sectors and rural society and to more food security in Japan and developing countries.

Notes

1) OECD, *National Policies and Agricultural Trade*, Paris: OECD, 1987, p. 52-53.
2) Ibid., p. 52.
3) Ibid., p. 56.
4) FOB import value is adjusted by the coefficient of 1.07 to be balanced with CIF import value.
5) FAO, *Agriculture: Toward 2010*, Rome: FAO, 1993.
6) Ibid.
7) Pierre Crosson, "Future Supplies of Land and Water for World Agriculture," Chapter 6 in Nurul Islam, ed., *Population and Food in the Early Twenty-First Century: Meeting Future Food Demand of an Increasing Population*, Washington, D. C.: International Food Policy Research Institute, pp. 154-156.
8) L. Oldeman, R. Hakkeling, and W. Sombroeck, *World Map of the Status of Human-Induced Soil Degradation: An Explanatory Note*, second ed., Wageningen, The Netherland; Nailobi: International Soil Reference and Information Center and United Nations Environment Programme, 1991.
9) World Bank and UNDP, *Irrigation and Drainage Research: A Proposal*, Washington, D. C.: World Bank, 1990; P. A. Oram and Behjat Hojjati, "The Growth Potential of Existing Agricultural Technology," Chapter 7 of Nurul Islam, ed., *Population and Food in the Early Twenty-First Century: Meeting Future Food Demand of an Increasing Population*, Washington, D. C.: International Food Policy Research Institute, pp. 167-189, 1995.
10) P. Crosson, op. cit.
11) S. Postel, *Last Oasis: Facing Water Scarcity*, The Worldwatch Environmental Alert Series, New York: W. W. Norton, 1992.
12) L. R. Brown, "Future Supplies of Land and Water Are Fast Approaching Depletion," Comment on Chapter 6 in Nurul Islam, ed., *Population and Food in the Early Twenty-First Century: Meeting Future Food Demand of an Increasing Population*, Washington, D.

C.: International Food Policy Research Institute, pp. 161-166, 1995.

13) Donald Duvick, "Plant Breeding and Biotechnology for Meeting Future Food Needs," Chapter 9 in *Population and Food in the Early Twenty-First Century: Meeting Future Food Demand of an Increasing Population*, Washington, D. C.: International Food Policy Research Institute, p. 222, 1995.

14) R. Evenson and C. David, "Rice Research and Productivity," Chapter 3 in *Adjustment and Technology: The Case of Rice*, Paris:OECD, pp. 57-84, 1990 and ふ- Donald Plucknett, "Prospects of Meeting Future Food Needs Through New Technology," Chapter 8 in *Population and Food in the Early Twenty-First Century: Meeting Future Food Demand of an Increasing Population*, Washington, D. C.: International Food Policy Research Institute, p. 208, 1995..

15) Donald Plucknett, op. cit., p. 208.

16) There is an opinion that Chinese grain yield will increase much more than now because of this underestimation and the comparison of yield with Japan, Britain and America. Zenpei Gen, "Structural Analysis of Chinese Food Economy and Supply and Demand Prospects", *Azia Keizai*, 37-2, February 1996, pp. 33-62.

17) USDA, ERS, Rice, *Situation and Outlook Yearbook*, p. 13. Nov. 1995.

18) Balu Bumb, "Growth Potential of Existing Technology is Insufficiently Tapped," Comment on Chapter 7 in *Population and Food in the Early Twenty-First Century: Meeting Future Food Demand of an Increasing Population*, Washington, D. C.: International Food Policy Research Institute, pp. 191-205, 1995.

19) Lester R. Brown, *Full House*, Norton, 1994.

20) Evenson and David, op. cit., pp. 57-84, and Personal communication with Professor Takeshi Horie (crop science) in Kyoto University.

21) IRRI, *1993-95 IRRI Rice Almanac*, Manila: IRRI, p. 8, 1993.

22) IRRI, *Rice in Crucial Environments*, Manila: IRRI, p. 8, 1993 and IRRI, *1993-95 IRRI Rice Almanac*, p. 6.

23) Oram and Hojjati, op. cit., p. 168.

24) Oram and Hojjati, op. cit., p. 188.

25) Balu Bumb, op. cit., pp. 194-203

26) IRRI, *1993-95 IRRI Rice Almanac*, p. 6.

27) Donald Plucknett, op. cit., p. 208 and Donald Duvick, op. cit., p. 223.

28) Donald Duvick, op. cit., p. 223 and IRRI, *1993-95 IRRI Rice Almanac*, p. 110.

29) Donald Duvick, op. cit., p. 224-225.

30) IRRI, *1993-95 IRRI Rice Almanac*, p. 110.

31) IRRI, *1993-95 IRRI Rice Almanac*, p. 8.

32) World Bank, *World Development Report 1995*, pp. 162-63.

33) USDA, ERS, *Rice, Situation and Outlook Yearbook*, Nov. 1995, Ap. 13.

34) Ibid.

35) Hiroshi Tsujii, "International Effects of Emergency Rice Imports by Japan — the Crisis to the Huge Poor in the Developing Countries —", *Kokusai Mondai*, No. 416, pages 37-52, November 1994.

36) L. R. Brown, op. cit.; M. W. Rosegrant, M. Agcaoili-Sombilla and N. D. Perez, *Global Food Projections to 2020: Implications for Investment*, Washington, D. C.: International Food Policy Research Institute, 1995; Kym Anderson, B. Dimaranan T. Hertel, and W. Martin, "Asia-Pacific Food Markets and Trade in 2005: A Global, Economy-Wide

Perspective," A paper commissioned for the International General Meeting of the Pacific Basin Economic Council, Washington, D. C., 20-22 may, 1996; D. O. Mitchell and M. D. Ingco, "Global and Regional Food Demand and Supply Prospects," Chapter 4 in *Population and Food in the Early Twenty-First Century: Meeting Future Food Demand of an Increasing Population*, Washington, D. C.: International Food Policy Research Institute, pp. 49-60, 1995.