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Central Intelligence Agency

Washington, D.C. 20505

2 December 2015

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This is a final response to your 1 July 2015 Freedom of Information Act (FOIA) request for **"a copy of the following six CIA documents:**

1. **FDD-6440, World Press Treatment of the Use of Gas in Vietnam (translation), May 6, 1965.**
2. **Potential Implications of Trends in World Population, Food Production and Climate, August 1974.**
3. **A Study of Climatological Research as it Pertains to Intelligence Problems, August 1974.**
4. **China: The Coal Industry, November 1976.**
5. **Deception Maxims: Fact and Folklore, April 1980, XD-OSD/NA.**
6. **The Biological and Chemical Warfare Threat, January 1997."**

We processed your request in accordance with the FOIA, 5 U.S.C. § 552, as amended, and the CIA Information Act, 50 U.S.C. § 3141, as amended. Our processing included a search for records as described in our 22 July 2015 acceptance letter.

We completed a thorough search for records responsive to your request and located the enclosed three documents, consisting of 114 pages, which we determined are releasable to you in their entirety. Because you are entitled to the first 100 pages free, and the cost for the remaining pages is minimal, in accordance with our regulations, as a matter of administrative discretion, there is no charge for processing your request.

Sincerely,

Michael Lavergne

Michael Lavergne
Information and Privacy Coordinator

Enclosures

Potential Implications of Trends in World Population, Food Production, and Climate

(1)

OPR-401
August 1974

C E N T R A L I N T E L L I G E N C E A G E N C Y

DIRECTORATE OF INTELLIGENCE
OFFICE OF POLITICAL RESEARCH

August 1974

POTENTIAL IMPLICATIONS OF TRENDS IN WORLD POPULATION, FOOD PRODUCTION, AND CLIMATE

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POTENTIAL IMPLICATIONS OF TRENDS IN WORLD POPULATION, FOOD PRODUCTION, AND CLIMATE

KEY JUDGMENTS

Trying to provide adequate world food supplies will become a problem of over-riding priority in the years and decades immediately ahead -- and a key role in any successful effort must fall to the US. Even in the most favorable circumstances predictable, with increased devotion of scarce resources and technical expertise, the outcome will be doubtful; in the event of adverse changes in climate, the outcome can only be grave.

The momentum of world population growth, especially in the less developed countries (LDCs), is such that even strong measures taken now to reduce fertility would not stop rapid growth for decades. Thus, most LDCs must cope with the needs of much larger populations or face the political and other consequences of rising death rates.

Demand for food rises inexorably with the growth of population and of affluence. Increases in supply are less certain. Man's age-old concerns about the adequacy of food supplies have resumed with particular urgency since the crop-failures of 1972.

The rich countries need have no fear of hunger, though the relative price of food will probably rise at times.

The poor, food-deficit LDCs must produce most of the additional food they will need to support their

NOTE: *This study was prepared by the Office of Political Research of the Central Intelligence Agency. It does not, however, represent an official CIA position. The views presented represent the best judgments of the issuing office which is aware that the complex issues discussed lend themselves to other interpretations.*

growing populations. They cannot afford to import it, nor is it likely they can count on getting enough aid from the food-exporting countries. They face serious political, economic, and cultural obstacles to raising output, however, and are in for considerable strain at the least, and probably for periods of famine.

The US now provides nearly three-fourths of the world's net grain exports and its role is almost certain to grow over the next several decades. The world's increasing dependence on American surpluses portends an increase in US power and influence, especially vis-a-vis the food-deficit poor countries. Indeed, in times of shortage, the US will face difficult choices about how to allocate its surplus between affluent purchasers and the hungry world.

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The implications for the world food situation and for US interests would be considerably greater *if* climatologists who believe a cooling trend is underway prove to be right.

> *If* the trend continues for several decades there would almost certainly be an absolute shortage of food. The high-latitude areas, including the USSR and north China, would experience shorter growing seasons and a drop in output. The monsoon-fed lands in Asia and Africa would also be adversely affected.
>
> US production would probably not be hurt much. As custodian of the bulk of the

world's exportable grain, the US might regain the primacy in world affairs it held in the immediate post-World War II era.

In the worst case, *if* climate change caused grave shortages of food despite US exports, the potential risks to the US would also rise. There would be increasingly desperate attempts on the part of powerful but hungry nations to get grain any way they could. Massive migrations, sometimes backed by force, would become a live issue and political and economic instability would be widespread.

In the poor and powerless areas, population would have to drop to levels that could be supported. The population "problem" would have solved itself in the most unpleasant fashion.

THE DISCUSSION

I. INTRODUCTION

The widespread crop shortfalls in 1972 and the energy and fertilizer crunches in '73 and '74 have raised anew the basic question of whether the production of food can keep pace with demand over the next few decades. Concern about the capability of many of the poorer countries to provide for their growing population is widespread and rising. Major international conferences planned for the second half of this year--i.e., the World Population Conference in August and the World Food Conference in November--will focus on various aspects of this question.

There is, moreover, growing consensus among leading climatologists that the world is undergoing a cooling trend. If it continues, as feared, it could restrict production in both the USSR and China among other states, and could have an enormous impact, not only on the food-population balance, but also on the world balance of power.

This paper briefly reviews present trends and projections for world population and food production under assumptions of "normal" weather, and then essays a necessarily tentative exploration of the ramifications of a cooling climate. A final section addresses the political and other implications for the US of its potential role as the main food exporter in an increasingly hungry world.

II. PEOPLE

World population is growing at ever faster rates. The annual increase in 1930 was about 1.1%; by 1960 it had risen to about 1.7%. It is now around 2.0% and may still be rising. In numbers, these translate to global totals of about two billion in 1930; three billion in 1960, and four billion by early 1975. At current fertility rates, population would total some 7.8 billion by the turn of the century. The UN medium forecast is for about 6.4 billion by 2000 AD; this assumes substantial declines in fertility between now and then. (See tables 1 and 2 in Annex I.)

Population is growing not because birth rates are rising--indeed they are steady or falling in a number of countries--but because death rates, especially infant mortality, have fallen so sharply.*

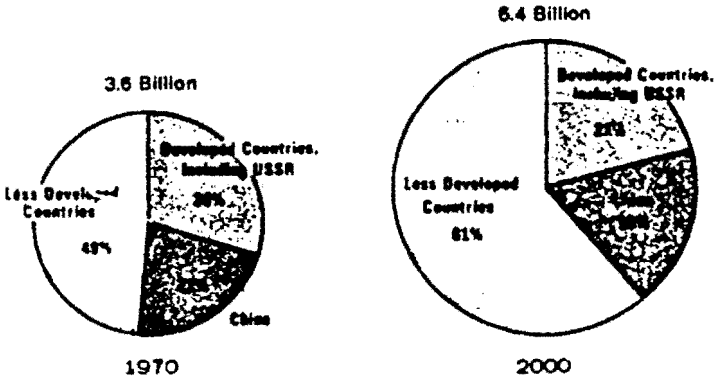
The increase in population is very unevenly distributed. In most of the developed countries, growth rates are low--the US is currently under 1% a year. But in most of the less developed countries (LDCs) growth rates are well over 2.5%, and in some of the LDCs they approach 3.5% a year. This difference in rates is such that while the peoples of the LDCs (and China) account for about 70% of the world total, by the turn of the century they will represent nearly 80% of the projected total, as illustrated by Figure 1.**

** Birth and death rates refer to numbers per hundred total population, and are thus expressed in percentages. Fertility, or fertility rates refer to the numbers of children per mother. The replacement rate is an average of 2.1 to 2.5 children per family, depending on mortality rates. This would lead to zero population growth only in the longer run. All such terms refer to natural growth and omit the effects of migration.*

*** China is not otherwise included in the group of LDCs in this review of population and food trends because its population growth is not so rapid; nor does it rely heavily on imported food.*

Figure 1

Change in Population Distribution 1970 and 2000



Based on UN "Medium" population projection

563937 7 74

Moreover, the momentum of population growth is so strong in the LDCs, largely because of the size of the group entering or approaching child-bearing age, that even if the developing countries were to adopt strong measures to lower fertility, it is almost certain that the natural rates of population growth would remain high over the subsequent one or two decades. And, even if fertility fell dramatically and quickly, the number of young couples is so large that population would not stop growing for at least five decades--barring, of course, a major rise in death rates. Without such measures, growth rates would remain high much longer.*

Given the growth rate and age structure of their current populations, it is thus certain that

* *If, Mexico, for example, with a current population of about 58 million, reached a replacement rate of fertility by 1980-85, its population would level off at about 110 million by the middle of the next century. If Mexican fertility did not drop to replacement levels until the year 2000, its population would level off at about 170 million in the last half of the next century. (Figure 2)*

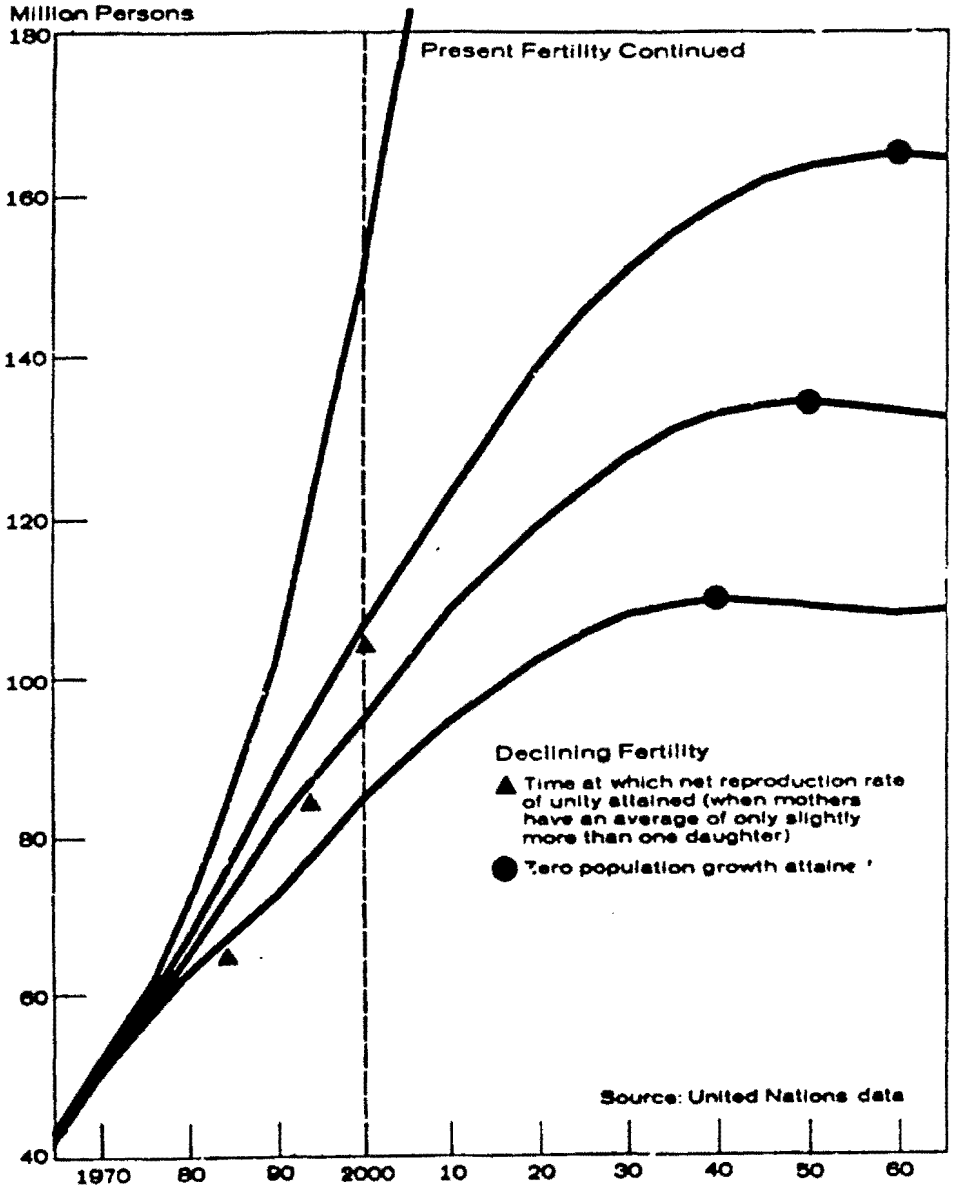
most LDCs will have to provide food for much larger populations before the end of the century or face the political and social consequences of rising death rates. Some will probably have to do both.

All population projections currently in use rest on the assumptions that infant mortality will continue to decline in the LDCs and that life spans will gradually increase, i.e., until they are near those in the developed countries.* Such assumptions in turn depend on some fairly optimistic expectations about improvements in public health and the general nutritional level of the more miserable segments of LDC populations. The projections also imply that wars, famine and plague (while not ruled out) will not be of sufficient magnitude to affect death rates

* *Under the current UN medium projections, life expectancy for the world as a whole rises from 56 (about today's level) to 66 by 2000 AD: for the LDC's as a group, it is projected to grow from about 54 to 64 over the same period. In large part, closing this gap will come from reductions in infant mortality rates which now range from 1 to 4 per 100 live births in the developed countries to 20 or more in the poor countries.*

Momentum of Population Growth, Mexico

Figure 2



materially on a global basis. For the purposes of this discussion, consideration of major or catastrophic wars is ruled out, but not the other great scourges--famine and plague. These may occur on a scale large enough to raise global death rates if food shortages become more severe and chronic than they have been in recent years.*

III. FOOD

If population grows as projected, the question of food is two-fold: will there be enough additional output to support the coming billions; and will the distribution systems--physical, administrative, and economic--be adequate to supply food where needed?

* *Famine and plague are closely related in that during periods of famine or poor nutrition, many succumb to diseases they could otherwise survive. Famine often causes the hungry to gather at food distribution points which facilitates the rapid spread of disease. Moreover, if social order including public health services falters, as frequently happens in such conditions, then prevention and treatment of such scourges as cholera and typhoid become less and less possible. For these and other reasons then, the avoidance of epidemics depends heavily on adequate food supplies.*

Need and Demand

A recent UN Food and Agriculture Organization (FAO) study estimates that 20-25% of the peoples of most countries in Asia and Africa now suffer from serious under-nutrition. Implicit in almost all projections of the coming growth in demand for food are the assumptions that most LDCs will see no real improvement in the average diet over the next decade or two, and that there will be no widespread programs to alleviate malnutrition among the most ill-fed groups. Obviously, the *need* for food is and will continue greater than the *demand* for food, which implies ability to purchase.

Directly consumed cereals provide about half the world's food energy; consumed indirectly in the form of livestock products, they account for much of the rest. And this is where the difference in demand for food by rich and poor countries emerges most forcefully. It requires several pounds of grain to

produce a pound of meat. In effect meat eaters consume food energy twice--first in the form of feed-grain to grow the animal, and then the animal itself.* As income rises, there is an almost universal tendency to eat more protein, especially in the form of animal-products. Annual beef consumption in the US, for example, grew from 55 pounds a person in 1940 to 117 pounds in 1972. In the other industrial countries--Western Europe, Japan, and the USSR--dietary habits resemble those of the US in the 1940's. Since pastures and other natural sources of forage are no longer adequate to feed the animals currently raised for food in most places, increased demand for animal protein requires more grain and other food-stuffs like soybeans.

Forecasts of demand for food over the coming decades rest heavily then on two main factors: the

* *In South Asia, for example, most people live on about 400 pounds of grain a year. North Americans, at the other extreme, consume nearly a ton a year, but less than a fifth of it is eaten directly in the form of cereal, bread, etc. The rest is used indirectly as livestock-feed.*

growth of population, especially in the LDCs where demand is most affected by population changes; and income levels in the richer countries where demand is fueled by higher income as much as by population growth.*

Both the U.S. Department of Agriculture (USDA) and the Food and Agriculture Organization (FAO) have recently projected demand for food over the next decade. For the world as a whole they forecast an annual growth of 2.3 to 2.5%. The lower estimate by the USDA is based on the assumption that there will be practically no increase

* *While it is clear that projected demand for food includes protein (in the form of fish, soybeans, pulses, peanuts, etc.) the role of grain as food and feed is so great that this discussion will hereafter focus on grain alone. Protein supplies themselves will be heavily dependent on grain availability since the fish catch has not been growing much in the past 5-6 years; soybeans are not very responsive to fertilizer and hence increased output depends largely on planting more acres (on land that is also suitable for grain). In short, the bulk of protein increases will depend on feed-grains.*

in per capita consumption in the LDCs, and some growth in income and grain imports by the rich countries. The higher FAO forecast is based on more optimistic assessments of economic development in the LDCs where food demand is expected to grow 3.7% a year, which implies some increase in per capita consumption.

Neither forecast can be certain of demand in the developed countries because so much will depend on their policies. This applies with particular force to estimates of the amount of grain that will move in trade between richer countries. For example, will the governments of the USSR and East Europe decide to provide more meat per capita, even if they have to import extra grain, or will they tighten their belts in poor harvest years as they did in the 1960's? Such decisions will have considerable impact on the global demand for grain over the next decades. In any event, it seems plausible to assume that world demand will grow at least 2.3% a year on average and possibly faster.

Supply: The Record

Food production has increased at a fairly steady pace over the past several decades--about equally as fast in the developed and less developed countries. In aggregate terms, the LDCs' performance was impressive. Total food output rose nearly 66% between 1954 and 1973, or more than 2.5% a year. They did even better in grain production: the area planted to grain rose by about 35%, and yield rose nearly as much.

Since population grew vigorously in the LDCs, however, per capita production changed very little: more recently, per capita consumption has probably declined in many LDCs. A number of countries experienced periods of severe malnutrition and growing dependence on food imported from the developed countries.*

* *USDA estimates indicate a decline in grain consumption per capita in Mexico and Central America, most of the rest of South America except Argentina, Central Africa, and South East Asia. For LDCs as a group, the USDA estimates annual consumption in kilograms per capita as follows: 1964-66 - 166, 1969-71 - 173, 1971-72 - 158, 1972-73 - 161, 1973-74 - 164.*

The world pattern of grain trade has changed over the same period. Most regions have become net importers, and the volume of such imports has risen, as indicated by the following table.

Net Exports (+) and Imports (-) in million metric tons[1]

	1948-52	1960	1966	72/73[2]	73/74[2]
North America	+ 23	+ 39	+ 59	+ 89	+ 92
Latin America	+ 1	0	+ 5	- 3	- 2
Western Europe	- 22	- 25	- 27	- 18	- 20
East Europe & USSR	0	0	- 4	- 26	- 12
Africa	0	- 2	- 7	- 1	- 5
Asia	- 6	- 17	- 34	- 38	- 49
Australia & New Zealand	+ 3	+ 6	+ 8	+ 7	+ 9

1- *Totals will not balance because of stock changes and rounding.*
2- *Different series, but indicative of trend. 73/74 are preliminary.*

Twenty years ago, North America exported mainly to Western Europe; most other regions were basically self-sufficient. Now, the whole world has become dependent on North America for grain--feed grains mainly to Europe and Japan, food grains elsewhere. (See Figure 3.) The US now supplies nearly three-fourths of the net global exports, and Canada between 15 and 20%.

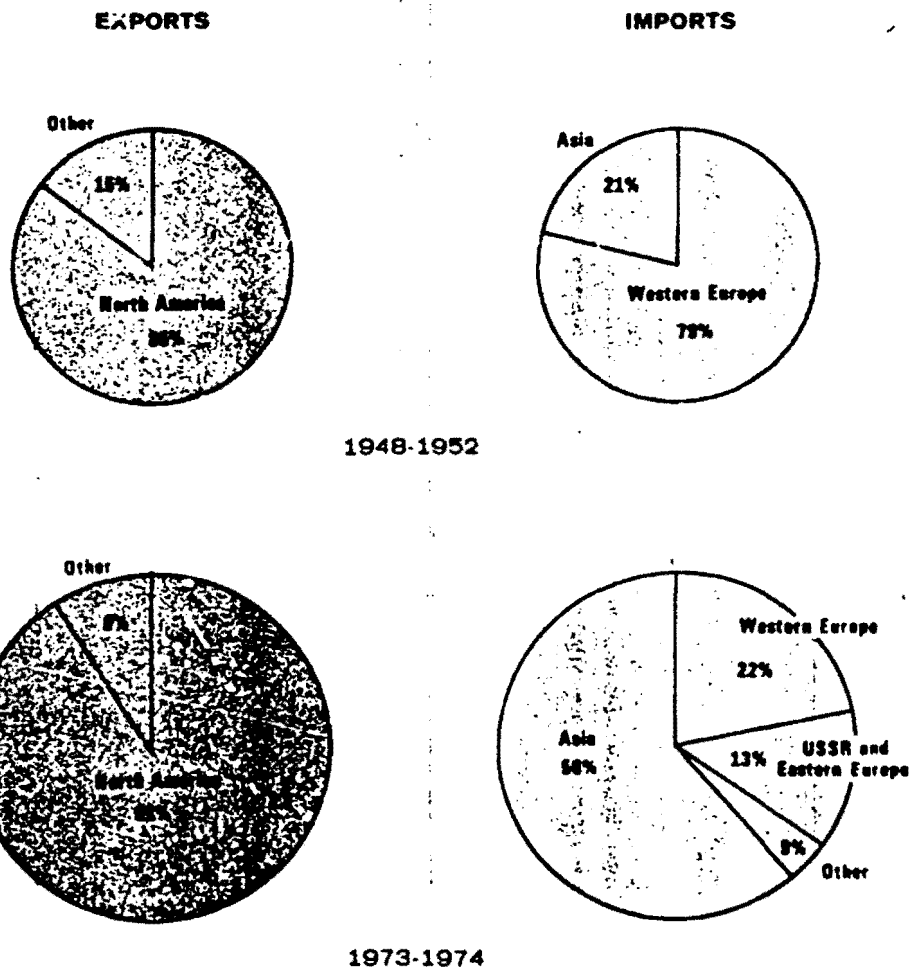
In 1972, India's monsoon season was poor, China had drought in the north and floods in the south, the USSR experienced both drought and a short growing season, and drought was particularly oppressive in parts of Central America and Africa. The results were starvation for some, hunger for many, a rapid rise in food prices everywhere--and a drastic drawdown of existing world stocks of grain.

Supply: Current Prospects

Until very recently, there were two major factors available to cushion the effects of poor harvests: the huge grain stocks in the US (and to a lesser extent in other exporting countries) and the acreage held out of production in the US land bank. Now, stocks are so low they cannot make up for a crop failure in any major area this year. And almost all the US land reserve is back in production. Thus, unless there is exceptionally good weather this year and next, stocks cannot be rebuilt quickly.

Figure 3

Direction of Net Grain Trade
1948-52 and 1973-74 (prelim.)



Harvests this year and next are therefore of critical importance, especially to the poor food-deficit countries.* For these countries a poor or mediocre harvest could be devastating. Unless, for example, the Indian monsoon improves soon, India will have to import far more grain than it had planned to. Yet, the world-wide inflation of energy, fertilizer, food and other prices has imposed severe strains on its foreign exchange holdings. Mediocre harvests in other major grain-producing countries would drive prices even higher.** In such a situation, there might not be enough surplus to keep India from famine, even if it could afford the cost of imports--or if it somehow got grain on concessional terms.

The current shortage of food affects the developed countries quite differently. For the rich,

** Not all LDCs fall into this category. Many, especially the oil producers, will be able to afford food imports.*

*** As indicated by Tables 3-4 in Annex I, less than 10% of the world's harvest constitutes net exports, but relatively small tonnages make a critical difference for food-deficit countries and have a large impact on price.*

there are the annoyance and domestic repercussions of high food prices; and for the main importers, an adverse impact on the balance of payments. But there is no fear of real hunger (except perhaps among the poorest segments of their population). The major food exporters--the US and Canada--can expect a sizeable boost in earnings from agricultural exports. But if global harvests are poor, these exporting countries will face the difficult choice of whether to sell food to the richer importers or to give it to the poor ones when there is not enough to cover both needs. In short, famine relief on any major scale would have to come from reduced consumption by the well-fed--which would be a difficult and divisive process, even with the best will in the world.

The Longer Range Outlook

Assuming that the world squeaks by the next few years with good harvests, what of the longer run? As the recent FAO study on the future demand

for and supply of food stresses, it is far more difficult to forecast the growth of food production than the rise in demand for it. Here, there is a wide range of opinion among the experts which may be put into two, albeit oversimplified, schools of thought--the "optimistic" and the "pessimistic." They differ far more on their assessments of prospects over the longer run than for the next few years.

The optimists stress the theoretical capacity of world agriculture to increase output, by a variety of technical measures, 2-3% a year until at least sometime in the next century.

> --On the basis of past performance and improvement in technology, rising demand can be met, provided (1) normal weather prevails (i.e., average conditions similar to the past few decades which cancel out both unusually good and unusually bad years); (2) adequate inputs of fertilizer, pesticides, etc., are available at reasonable

prices and (3) prices paid to farmers provide adequate incentives to raise output.

--According to US Department of Agriculture estimates, the US is capable of a 50% increase in feed-grain production by 1985, and thus of providing for almost any foreseeable increase in world import demand for coarse grains (mainly feed grain). Moreover, USDA considers that wheat production could increase by at least a third in the same period. Such gains would come almost entirely from higher yields.

--Under its conservative projections of demand, the USDA foresees cereal production capacity growing faster than consumption: hence the feasibility of rebuilding world reserve stocks, and the possibility of lower prices.

According to the optimists, net grain imports by LDCs would rise from 15.5 million metric tons (1969-71

average) to 40 - 45 million metric tons in 1985. This assumes that production in these countries could grow slightly faster than 2.6% a year while demand would grow about 3%.

In terms of per capita consumption in the LDCs, these projections imply no appreciable change over this period--only from 181 kilograms a person to 186 by 1985. In short, even the optimistic school of thought projects no real improvement in nutrition for the very poor food-deficit LDCs who make up the bulk of total LDC population. Moreover, many of the poor countries will be unable to pay market prices for the projected level of imports especially if the cost of other essential imports like oil remains high. Thus, unless even the optimistic projections about production in the LDCs are too low, many of the food-deficit LDCs are likely to be in for serious trouble within the next 5-10 years.*

* *FAO projections of food demand and output assume a slightly greater increase in LDC consumption, hence a larger volume of imports. They, too, are quite pessimistic about LDC ability to pay for such imports and hope LDCs can rely on aid. In the 1950's and 60's food aid (much of it US PL 480) amounted to about a third of the total food imports of the LDCs. Such shipments have declined sharply in the past couple of years, however, as the relative cost of food has risen and surplus stocks have been used up.*

The pessimists are dubious about the ability of the world, especially the LDCs, to increase food production at the rates discussed above. They cite a number of very important constraints on ever-rising output.

--Additional arable land is practically unavailable in much of the world, including China, India, Japan, and other parts of Asia. Much of the arable areas of China, for example, are already double and triple cropped. Most additions will require costly capital improvements such as swamp drainage, river diversion, complexes of dams and irrigation canals, or construction of desalting plants to make ocean water available. Moreover, the world as a whole is losing several million acres of arable land each year to erosion, salinization, and the spread of cities, industry and roads.*

* *Until about 1930, most of the increase in food production came through putting additional land under cultivation and/or having more people at work on the land. Since then, technological improvements--new strains of seed, fertilizer, irrigation, pesticides and mechanization--have played an increasingly important role in raising output.*

--Thus, nearly all of the increased demand for food will have to be met by higher yields. There are some indications that the rate of growth in LDC output has slowed in recent years: the cheaper and more promising projects have been completed; the most receptive and dynamic farmers have, in many cases, already adopted the new varieties and more modern methods.

--In the developed countries, yield gains may also be slowing. Costs are rising rapidly and it requires ever greater input to achieve an additional unit of output.

--Clearly, the greatest potential for increased food production over the longer run lies in the LDCs, where yields are far below those of the developed countries.*

* *Rice yields in India average about 1/3 those of Japan; corn in Thailand and Brazil less than a third of the US.*

But the social, political and economic obstacles to such development are, in the opinion of the pessimists, formidable.

--Adequate incentives and inputs for farmers imply a major shift in the rural-urban terms of trade in most LDCs. If food prices paid farmers go up, the urban poor cannot afford the increase. Either they get subsidized food, or starve. Few LDCs have been willing to pay adequate subsidies yet, nor is it clear where they could get the necessary funds to do so.

--Moreover, the political commitment to agriculture has thus far been lacking. In most LDCs, the governing policy has been either to ignore or to soak the peasants in order to promote industry and keep the city-dweller reasonably content. Reversal of this policy would require enormous inputs of capital and skilled personnel, both in notoriously short supply in most LDCs.

The optimists would argue that as relative food prices rise, as rise they must in the food-deficit LDCs, market forces will call forth increased production. Hopefully they are right on this, but the social and political turmoil implicit in such a price rise is considerable. And large numbers of the very poor would be likely to succumb to famine or hunger-induced diseases long before a new balance were achieved.

In short, whichever school of thought proves out, it seems clear that the world of the poor, at least, will experience continued food shortages and occasional famine over the coming decades. Under either assumption, the developed countries can expect to remain well fed, though perhaps not able to raise their consumption of grain-fed animal products as fast as they might want to. The disparity between the rich and poor is thus likely to get even wider. And the world's dependence on North American agriculture will continue to increase.

IV. CLIMATE*

The precarious outlook for the poor and food-deficit countries, and the enhanced role of North American agriculture in world food trade outlined above were predicated on the assumption that normal weather will prevail over the next few decades.** But many climatologists warn that this assumption is questionable; some would say that it is almost certainly wrong.

Perhaps the simplest worry is marked variation within the prevailing weather patterns. The US middle-west has had moderate to severe droughts every 20 to 25 years--e.g., 1930's, mid-1950's--as far back as

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* *Discussion of the nature and impact of possible climate change is, of necessity, highly speculative and therefore controversial. Various experts will disagree with some or many of the implicit assumptions. For example, the Office of Economic Research thinks that too little is known about possible climate change and its potential impact on food production to warrant a discussion of possible adverse implications for food supply.*

** *Normal weather is defined by climatologists as that which has been experienced in the three previous decades.*

the weather records go. If this pattern holds, the main US granary (now also the mainstay of world grain trade) could expect drought and consequent crop shortfalls within the next several years. If world grain stocks were near today's low levels when this occurred, there would be a severe pinch on world food supplies even if all the other main producing areas had average to good weather.

The extent of this shortage would of course depend on the degree of U.S. drought and its duration. But almost any drop in U.S. output during the next several years would have considerable impact on the price and on the availability of food for the poor food-importing nations.

Such a cyclical phenomenon, however, would probably last less than a decade. While its impact could be severe, there would be reasonable hope of improvement within a short time.

Far more disturbing is the thesis that the weather we call normal is, in fact, highly abnormal

and unusually felicitous in terms of supporting agricultural output. While still unable to explain how or why climate changes, or to predict the extent and duration of change, a number of climatologists are in agreement that the northern hemisphere, at least, is growing cooler.*

--Iceland, because of its location, is a good indicator of changes in the whole Northern Hemisphere. The weather records and evidence for Iceland indicate that the past 4 decades were the most abnormal period in the last 1000 years--much much warmer. (See Figure 4.)

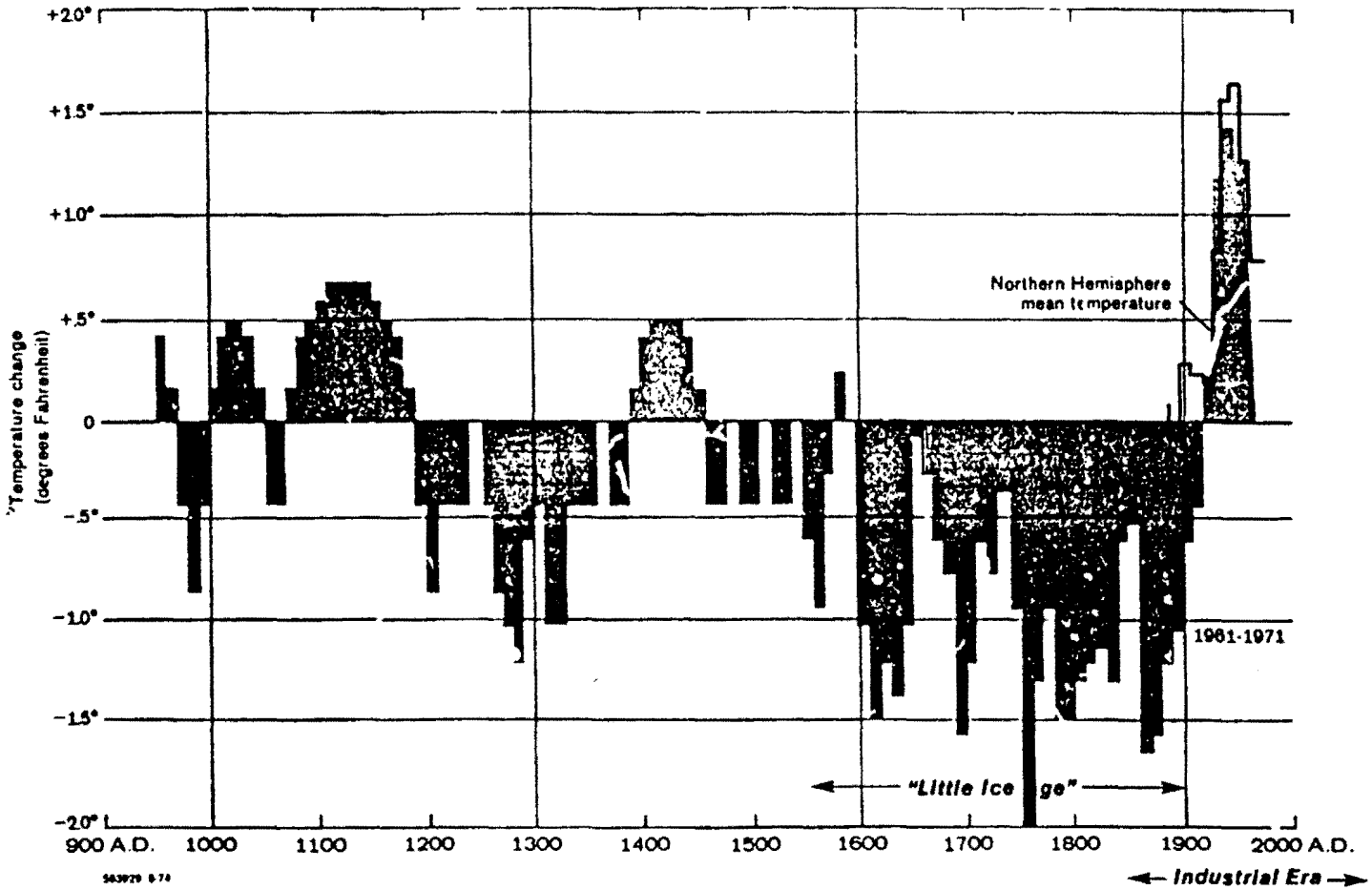
--The arctic ice area has perceptibly increased in the past few years.

--The English growing season has been shortened by a week or more since the 1940's.

* *According to Dr. Hubert Lamb--an outstanding British climatologist--22 out of 27 forecasting methods he examined predicted a cooling trend through the remainder of this century. A change of 2° - 3° F. in average temperature would have an enormous impact.*

A thousand-year history of Iceland's temperature

Figure 4



The best estimates of climate over the past 1600 years indicate that major shifts have taken place more than a dozen times. The maximum temperature drop usually occurred within 40 years of inception of a cooling trend; and the earliest return to "normal" required 70 years.

A number of meteorological experts are thinking in terms of a return to a climate like that of the 19th century. This would mean that within a relatively few years (probably less than two decades, assuming the cooling trend began in the 1960's) there would be broad belts of excess and deficit rainfall in the middle-latitudes; more frequent failure of the monsoons that dominate the Indian sub-continent, south China and western Africa; shorter growing seasons for Canada, northern Russia and north China. Europe could expect to be cooler and wetter.*

** For a layman's explanation of one of the more plausible climate theories accounting for such changes, that of Dr. Reid Bryson, see Annex II.*

Of the main grain-growing regions, only the US and Argentina would escape adverse effects. In both, the cooler climate at the higher latitudes could be offset by shifting crop-belts equator-ward. In the US, during the 1800's, the mid-west grain areas were cooler and wetter; the southwest was hotter and drier, and the north-east slightly cooler.

Too little is known about the effect of such climate changes on yield to predict the quantitative impact on production in the US or in other areas; but some general effects of a major climate change in terms of the global grain output are suggested.

--US output might be unaffected or even slightly enhanced,

--a shorter growing season would restrict production in the high latitude areas, like Canada and the USSR.

--More frequent monsoon failures in South and South-east Asia would significantly reduce grain output there.

--China would be hit by both cooling in the north and monsoon failures in the south.

Moreover, in periods when climate change is underway, violent weather--unseasonal frosts, warm spells, large storms, floods, etc.--is thought to be more common. The change itself would not be smooth, and even if the drop in temperature were slow, the disruptive effect of violent weather on crops might be considerably more adverse than mere cooling. But too little is yet known to be definite about this.

It is clear, however, that *if* a cooling trend were to have adverse effects on high-latitude and on the monsoon-fed lands, it would pose a food-population problem of the gravest nature. Many LDCs are already expected to encounter serious difficulties in increasing agricultural output as fast as their populations grow; more frequent droughts would almost certainly frustrate whatever hope of success they had.

During the period of "normal" (or abnormally good) weather (1930s-1960s) which now may be ending,

the population of the world grew more than 50%. Moreover, most major dams and irrigation systems were built during this period and based on prevailing rainfall patterns. If these patterns changed, such systems would be less useful. Most of the hybrids and all of the "green-revolution" strains were developed to use the warmth and moisture prevailing in this period. Significant change in temperature or rainfall pattern could negate most of these advances in yield. Experts are too uncertain about the possible magnitude of the cooling trend and change in rainfall to be able to chart the effects on irrigation systems and hybrids, but production in many countries almost certainly would be cut.

Clearly, agronomists could develop new strains more suitable to different weather and every effort would be made to counter the adverse effects of a climate change. New methods of manufacturing food-stuffs and stretching what was available would help, e.g., texturized vegetable protein, milk made directly

from grass. Unconventional food sources, like the yeasts that can be made to grow on petroleum, would also be tried. But in most cases the cost of such supplemental foods is still greater than natural foods and would thus be of little help to the poorest and neediest groups for a decade or more.

The USSR, China, and South Asia would probably need large imports. How much--the most critical question--would depend heavily on how far and how fast the climate patterns changed. If the cooling trend were marked and persistent, then a physical shortage of food would seem inevitable. That is, no matter what the price or the distribution arrangements, there would not be enough produced to feed the world's population--unless the affluent nations made a quick and drastic cut in their consumption of grain-fed animals. Even then there might not be enough.

V. POLITICAL AND OTHER IMPLICATIONS

With or without "normal" weather, the US is almost certain to increase its dominance of the

world's grain trade over the next couple of decades. This enhanced role as supplier of food will provide additional levers of influence, but at the same time will pose difficult choices and possibly new problems for the US. The magnitude and range of implications differ radically depending on whether "normal" or much cooler weather is postulated.

Assuming Normal Weather

The growing dependence of poor food-deficit LDCs on imported grain and the continued desire of affluent peoples to increase their consumption of animal products promise generally strong markets for US grain exports and considerable benefits to the US balance of payments. Moreover, ability to provide relief food in periods of shortage or famine will enhance US influence in the recipient countries, at least for a time.

This dependence is also likely to lead to resentment of the US role on the part of the dependent

countries. Nevertheless, many will find it expedient to accommodate US wishes on a variety of issues. Others, perhaps with the backing of the USSR or China, may seek to establish some international controls over the allocation of world food stocks.

The US, for its part, will face the difficult and recurring issue of where its grain should go. In times of shortage when food prices rise, it will be hard to decide how much should be reserved for domestic consumption, how much should be sold at high prices, and how much should be given in aid to the needy. Each decision will have domestic and balance of payments repercussions, and will engage the humanitarian impulses of the country. Moreover, it may be difficult to chose among LDCs as recipients. Whatever the choices, the US will become a whipping boy among those who consider themselves left out or given only short shrift. The few other nations which might have some surplus will be tempted to use it for their own political ends.

There will probably be a number of times when there is not enough surplus: for example, a repeat of the crop shortfalls of 1972 when a number of major agricultural areas simultaneously experienced bad weather. If food stocks were low at the time, there would not be enough to supply the food-deficit LDCs and the feed-grain needs of the affluent countries. The very poor LDCs would almost certainly be unable to pay for the necessary imports and, even with aid, many would face famine.

The elites of many LDCs tend to regard periodic famine as either natural or at least beyond their power to prevent, e.g., Bihar in 1967, Ethiopia and the Sahelian states in 1973. But the rural masses may become less docile in the future and if famine also threatens the cities and reduces the living standards of the middle classes, it could lead to social and political upheavals which cripple governmental authority. The beleaguered governments could become more difficult to deal with on international issues either because of a collapse in

ability to meet commitments or through a greatly heightened nationalism and aggressiveness.

Developed countries that import large amounts of grain need not fear hunger or real privation, but will experience additional financial strain in years when crops are mediocre or poor. In such times, a sharp rise in food prices will affect their living standards. It has been decades since any rich country has been short of food and such an unfamiliar situation could generate great social and political stress. The US, as potential supplier, would gain influence; it might also be blamed for part of the shortage.

In sum, if the weather is "normal", it is essentially the poorer LDCs that will become ever more dependent on US food exports. Many will be unable to increase their own exports enough to pay for such imports and will either have to get food on concessional terms or face increasing shortages including a degree of famine which applies a

Malthusian check on their population growth. This will pose problems for the US and other rich countries, particularly if the affected LDCs decline into an ungovernable state of confusion.

Assuming the Cooling Trend Continues

A discussion of the implications of a cooler climate within the next several decades must, necessarily, be highly speculative. Yet even tentative assessments of the potential prospects may be useful in view of the evidence of cooling that now exists. One obstacle to more definite consideration is that climatologists are not able to predict how far the cooling trend might go. In the next 5 paragraphs, the discussion is based on the assumption of cooling great enough to cut the production of higher latitude areas (Canada, the USSR, and north China) and increase the frequency of drought in the monsoon-fed countries. It further assumes that US surpluses would still cover most needs, except in bad years. The last two paragraphs assume that the regression in weather reaches

the point where even the best efforts of the US would not normally be sufficient to meet the minimum needs of the major food-deficit areas.

In a cooler and therefore hungrier world, the US's near-monopoly position as food exporter would have an enormous, though not easily definable, impact on international relations. It could give the US a measure of power it had never had before--possibly an economic and political dominance greater than that of the immediate post-World War II years.

A substantially cooler climate could add new and powerful countries to the list of major importers and reduce Canada's exportable surplus. Among the most immediate effects would be rapid increases in the price of food in almost all countries, which would create internal dislocations and discontent. The poor, within countries and as national entities, would be hardest hit. What is happening now to the poor in India and in drought-stricken Africa is probably a pale sample of what the food-deficit areas might then experience.

In many LDCs, the death rate from malnutrition and related diseases would rise and population growth slow down or cease. Elsewhere, there might be waves of migration of the hungry towards areas thought to have enough food. The outlook then would be for more political and economic instability in most poor countries as well as for growing lack of confidence in leaders unable to solve so basic a problem as providing food.

For the richer countries, the impact would be mitigated, at least, by their very wealth. While standards of living in countries needing to import large quantities of food would probably decline, there would be little danger of starvation. Nevertheless, there would be varying degrees of economic dislocation and political dissatisfaction whose results would be very difficult to forecast.

In bad years, when the US could not meet the demand for food of most would-be importers, Washington would acquire virtual life and death power over the fate of multitudes of the needy. Without indulging

in blackmail in any sense, the US would gain extraordinary political and economic influence. For not only the poor LDCs but also the major powers would be at least partially dependent on food imports from the US.

In the worst case, where climate change caused grave shortages of food despite US exports, the potential risks to the US would rise. There would be increasingly desperate attempts on the part of the militarily powerful, but nonetheless hungry, nations to get more grain any way they could. Massive migration backed by force would become a very live issue. Nuclear blackmail is not inconceivable. More likely, perhaps, would be ill-conceived efforts to undertake drastic cures which might be worse than the disease; e.g., efforts to change the climate by trying to melt the arctic ice-cap.

In the poor and powerless areas, population would have to drop to levels that could be supported. Food subsidies and external aid, however generous the donors might be, would be inadequate. Unless

or until the climate improved and agricultural techniques changed sufficiently, population levels now projected for the LDCs could not be reached. The population "problem" would have solved itself in the most unpleasant fashion.

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The potential implications of a changed climate for the food-population balance and for the world balance of power thus could be enormous. They would become far clearer and possibly more manageable if the extent of possible cooling were thoroughly investigated and if the potential impact of that cooling were quantified.

ANNEX I

Tables on Population Growth and on World Grain Production and Trade

Table 1

World Population Projections

	Assuming Constant Fertility		Assuming Declining Fertility*	
	Millions	Growth Rate**	Millions	Growth Rate
1970	3,600	.....	3,600	.....
1985	5,200	2.4%	4,858	2.0%
2000	7,822	2.8%	6,407	1.9%

*UN "medium" projection.

**Annual average rate since preceding date.

Table 2

Regional Distribution and Growth Rates of Population: 1970–2000 (UN projections, medium variant)

	1970	1985	2000	Annual Average Growth Rate 1970-2000
	Millions			*Percent*
Developed Countries	1,084	1,234	1,368	0.8
Western	736	835	920	0.7
Of which				
US	205	236	264	0.9
Communist	348	399	447	0.8
Of which				
USSR	243	283	321	0.9
Less Developed Countries	2,537	3,624	5,039	2.3
Communist	794	1,007	1,201	1.4
Of which				
China	758	955	1,127	1.3
Other	1,743	2,618	3,838	2.7
Far East	49	66	83	1.8
Other Asia	1,090	1,623	2,341	2.6
Africa	352	536	834	2.9
Latin America	248	384	572	2.8
World Total	3,621	4,858	6,407	1.9

Table 3

Total Grains (wheat, coarse grain, and milled rice): Production, Disappearance, and Net Trade
(Million metric tons)

Region or country	1964/65–1966/67			1968/70–1971/72			1971/72			1972/73[2]			1973/74[3]		
	Prod.	Disap.	Net trade[1]	Prod.	Disap.	Net trade[1]	Prod.	Disap.	Net trade[1]	Prod.	Disap.	Net trade[1]	Prod.	Disap.	Net trade[1]
Developed															
United States	175.1	144.7	43.3	206.7	168.3	39.3	236.5	174.2	60.0	226.8	179.5	70.1	239.2	177.7	74.4
Canada	33.1	18.1	14.2	34.8	22.4	14.7	38.8	23.5	18.4	35.6	23.6	18.7	37.6	22.9	17.1
EC-9	79.6	100.0	-20.0	93.2	110.4	-16.6	100.4	112.0	-14.3	103.1	117.4	-13.1	106.4	118.4	-12.5
Other Western Europe	22.8	28.2	-5.8	29.0	33.9	-5.0	32.6	35.7	-4.6	30.2	36.5	-5.2	28.5	36.5	-7.4
Japan	14.0	23.9	-10.3	12.7	28.2	-14.4	10.9	25.8	-15.0	11.5	29.4	-16.6	11.6	30.2	-18.8
Australia and New Zealand	12.5	5.3	7.0	14.9	6.0	10.8	15.4	6.8	12.1	11.0	4.7	7.3	17.3	6.7	8.8
South Africa	7.9	5.6	0	10.1	6.9	1.2	11.7	7.3	2.9	6.3	7.0	3.4	10.3	7.8	.3
Total	346.0	325.8	28.3	403.4	376.1	30.0	446.3	388.3	39.8	424.5	400.7	14.4	450.1	400.2	61.9
Communist															
East Europe	64.8	71.7	-7.0	75.0	82.2	-7.3	82.1	90.1	-8.8	87.4	94.4	-6.6	89.2	95.1	-6.3
USSR	139.6	139.9	-.2	165.8	164.9	4.0	173.7	178.1	-5.8	160.1	179.1	-19.0	204.2	209.4	-5.2
China	179.6	144.2	-4.5	139.3	142.4	-3.1	164.0	166.3	-2.3	160.6	165.9	-5.3	168.0	176.3	-8.1
Total	344.1	355.8	-11.7	403.1	409.5	-6.4	419.8	431.5	-16.7	408.1	439.4	-30.9	461.4	481.1	-19.6
Less developed															
Mexico and Central America	13.7	14.3	-.5	16.0	18.0	-1.8	16.8	19.4	-2.1	14.8	19.2	-4.0	16.3	20.4	-4.0
Brazil	17.0	18.1	-1.9	20.6	21.7	-.7	20.0	23.3	-.8	19.4	22.4	-2.7	21.9	24.0	-2.4
Argentina	17.7	8.7	10.2	19.3	10.7	8.3	13.5	10.3	7.6	22.2	11.3	7.6	20.8	12.0	9.2
Other South America	7.3	9.0	-1.8	7.8	10.8	-3.1	7.4	11.4	-3.8	7.2	11.5	-4.3	7.2	12.4	-5.1
North Africa	11.6	14.8	-3.2	15.0	18.3	-3.3	15.6	18.8	-3.3	16.4	19.5	-3.2	15.0	19.1	-4.3
Central Africa	27.7	28.3	-.7	30.7	31.8	-1.0	30.9	31.9	-1.2	29.2	30.2	-1.0	27.0	28.3	-1.3
West Asia	23.9	28.4	-2.5	29.4	34.2	-5.1	30.5	33.8	-6.6	32.1	35.8	-3.4	28.1	35.4	-6.1
South Asia	87.0	98.5	-10.1	114.1	118.0	-4.7	114.4	115.5	-3.5	109.9	121.0	-4.4	122.0	131.2	-8.5
Southeast Asia	20.6	16.3	3.4	23.6	22.0	3.0	25.0	21.1	4.2	21.3	20.6	1.0	25.7	22.5	3.1
East Asia, Pacific	24.5	27.8	-3.4	31.2	38.4	-7.7	32.4	40.1	-8.9	30.9	42.5	-9.9	34.0	44.5	-10.9
Total	262.0	262.2	-10.5	309.5	323.9	-15.5	308.5	325.6	-18.4	303.4	334.0	-27.7	318.0	350.8	-30.3
World total	952.1	943.8	6.3	1,116.0	1,109.5	8.1	1,174.6	1,145.4	4.4	1,136.0	1,174.1	9.8	1,229.5	1,232.1	12.0

[1] Minus indicates net trade imports. Totals may not add due to rounding or stock changes.
[2] Preliminary.
[3] Projected.
SOURCE: USDA, *World Agricultural Situation*, December 1973.

Table 4

Production, Disappearance, and Net Trade in Grain
(Wheat, coarse grain, and milled rice)

Country and region	1969-71			1985 Projection		
	Prod.	Disap.	Net trade*	Prod.	Disap.	Net trade*
	Million metric tons					
Developed						
United States	209.7	189.3	20.3	276.0	222.4	53.7
Canada	34.8	22.4	14.7	46.0	26.1	19.9
EC-9	93.2	110.4	-16.0	133.5	135.2	-1.7
Other Western Europe	29.0	2.9	-3.0	37.6	44.0	-6.2
Japan	12.7	28.2	-14.4	11.5	46.6	-35.1
Australia and New Zealand	14.9	6.0	10.8	22.7	8.5	14.1
South Africa	10.1	6.9	1.2	14.9	10.8	4.1
Total	403.4	370.1	30.0	552.4	383.6	68.8
Communist						
East Europe	73.0	80.2	-7.2	102.9	104.0	-1.2
USSR	168.8	164.9	4.0	227.3	227.6	-0.3
China	150.3	162.4	-3.1	209.7	214.0	-4.2
Total	402.1	409.5	-6.4	539.9	545.6	-5.7
Less developed						
Mexico and Central America	16.0	18.0	-1.6	25.3	30.2	-4.9
Brazil	20.6	21.7	-0.7	31.3	33.3	-2.0
Argentina	19.3	10.7	8.3	25.6	12.9	12.6
Other South America	7.6	10.8	-3.1	9.9	17.0	-6.9
North Africa	13.0	16.3	-3.3	23.0	33.3	-10.3
Central Africa	30.7	31.8	-1.0	40.2	44.6	-4.4
West Asia	29.4	34.2	-3.1	36.1	47.3	-11.2
South Asia	114.1	118.8	-4.7	180.0	188.6	-8.7
Southeast Asia	25.6	22.0	3.6	40.8	34.6	6.1
East Asia, Pacific	31.2	38.4	-7.7	47.6	60.9	-13.3
Total	309.5	324.9	-15.5	450.5	502.9	-42.9
World total	1,116.0	1,109.5	8.1	1,351.8	1,332.1	0.2

*Net trade may not equal the difference between production and disappearance because of stock changes. Minus indicates net imports.

SOURCE: USDA, *World Agricultural Situation*, December 1972.

ANNEX II: Climate Theory*

Professor Reid A. Bryson of the University of Wisconsin at Madison has developed a theory and begun to develop a weather forecasting methodology based upon it. He contends that the world is at the end of a golden era: that of benign climate and food surpluses. Moreover, climate change has set in, and it will be 40 to 60 years from now at a minimum (possibly centuries) before we can hope for equally benign weather. He reasons along the following lines.

The earth's atmosphere, hence its weather, is driven by the heat of the sun. Temperature differences--between pole and equator and between surface and upper air--constitute the main working parts of this heat engine and are responsible for pressure differences and the consequent flow of air masses.

* *This is a layman's review for laymen of one of the many theoretical descriptions of climate change that observers agree is occurring. For a fuller explanation of this and other theses, see the forthcoming paper from ORD, "A Study of Climatological Research."*

At the beginning of this century, temperatures were rising and the mound of cold air that covers the pole was contracting.* By about 1940 it had reached a relatively small size and more of the earth was dominated by warm air from tropical regions. But since about 1940, the earth has in fact cooled and the polar air mass has expanded.

Why has the earth cooled? There are three main factors involved affecting how much sunlight reaches the earth and how much is re-radiated into space: volcanic dust, man-made dust, and carbon dioxide. The transparency of the atmosphere to incoming sunlight and heat is affected by dust. The main variable sources of dust are volcanic activity and man-made pollution. In the early part of this century, volcanic activity decreased markedly and this increased transparency; temperatures rose.

* *These phenomena are of greater impact in the northern hemisphere for 2 reasons: there are many more people and much more land mass in that hemisphere.*

Bryson estimates that transparency was little affected by man's activities until about 1930 but that since then, man-caused dust has increased rapidly.* And, since the mid-1950's volcanic activity has again become important.

According to his theory, the earth would have cooled due to this dust even more than it has if it had not been for measurable and increasing amounts of carbon dioxide which man has put into the atmosphere by burning fuel (the greenhouse effect).

Temperature changes, though important, are less so than the circulation pattern they help engineer. And here, dust cools the polar regions proportionally more than the tropics. This increases the temperature difference between the two (the temperature gradient). Increased carbon dioxide warms the surface but not the upper atmosphere; this increases the vertical temperature gradient. These two gradients are the

* *Man-made dust includes wind erosion of soils left unprotected as well as the more familiar industrial pollutants.*

main factors that control atmospheric circulation and rainfall.

The net effect is cooler weather in the high latitudes (near the arctic air masses) and a shift southward of the subtropical high pressure areas. The latter control the northward movement of monsoon rain (in the northern hemisphere). This shift, in Bryson's opinion, accounts for the prolonged drought in the African Sahelian region.*

North (or poleward) of this sub-tropical high pressure belt, the general effect of temperature gradient changes seems to be that areas dependent on westerlies for rain will have less strong westerlies and hence less rain. Inland on the Eurasian and other large land masses, north-south swings of the polar front (the edge of the great polar air mass) will tend to dominate the weather picture more than in the recent warm period.

* *The main temperature change seems to be in the summer, where mean arctic temperatures have dropped 0.5° C. (nearly 1° F.) giving an increased pole to equator gradient of 0.1° C. (almost 0.2° F.) per 1000 kilometers. This would, according to the theory, lower the latitude of the sub-tropic high by more than 30 miles.*

Bryson expects a return to something like the climate of the last century, in which case the following tendencies could be expected:

--More rain in the northern half of the US; drier in Central Gulf Coast, southwest, and the northern Rockies. The winter wheat area and the range lands of the high plains would be much wetter. On balance, these changes would probably not affect US food production very much.

--a higher frequency of drought in India, as the northern limits of the monsoon are pushed southward. Perhaps as much as severe drought every three to four years in northern and northwest India.

--persistent drought in Sahelian Africa so long as the sub-tropic high pressure area stays where it is.

--shorter growing seasons in Canada, northern Europe, northern Russia and north China and consequent reduction in grain output.

--more frequent monsoon failures in South East Asia and the Philippines.

Control over volcanic activity is well beyond human capability. Nor does it seem likely that human societies could change their activity patterns so as to reduce the amount of man-made dust which now accounts for perhaps 20-30% of the total. Thus, if the theory is correct, it is reasonable to assume continued cooling and change in weather patterns unless or until volcanic activity slows again. Even then, man-made dust would remain as an important cooling factor.