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THE WORLD FOOD SITUATION

IMPLICATIONS FOR MISSOURI AGRICULTURE

Proceedings

AG SCIENCE WEEK FORUM

University of Missouri *College of Agriculture* *February 7, 1967*

Program

9:30 a.m. Presiding ..... Schell H. Bodenhamer
9:45 a.m. The World Food Situation ..... M. B. Gillis
11:00 a.m. World Population ..... Rex Campbell
11:40 a.m. LUNCH
1:00 p.m. Presiding ..... C. E. Klingner
Some Alternative Solutions to the Problem of Balancing World Food Production and Needs ..... Lawrence Witt
1:45 p.m. Prospects for Increasing Food Production ..... Emmett Pinnell
2:30 p.m. —Panel—
Implications for Missouri Agriculture
M. B. Gillis
Lawrence Witt
Emmett Pinnell
Rex Campbell
Jerry West, Moderator

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The World Food Problem and Limited Land Resources

M. B. GILLIS*

I have been asked to discuss this subject in its broad aspects, especially current food production, and potential food production versus population growth and food needs. Other speakers will discuss particular aspects of the problem in more depth.

The remarks which I make will emphasize the limited soils available for food production—the rapidly growing populations which must be fed from this land—and the possible means for making it most productive.

It is our hope that this material will serve to increase awareness of the existence of this problem as well as call attention to the responsibilities which we share as Americans.

Famine Present Today

Most of us think of famine as an event that used to happen, as something we read about in history books. *But, famine is present in the world today and in the next few years it will spread and in one way or another it will affect all of us.*

Perhaps of all daily essentials, few are more taken for granted and less appreciated in the United States than food. As a matter of fact, Americans in general are undoubtedly overfed. Even though we read in the newspapers disturbing reports that world population is increasing, it is hard for the attendant problems to penetrate our everyday consciousness. Perhaps we don't really believe there is a serious problem. Perhaps we, in this country, have been guilty of developing what the psychologists call "mind set."

It is difficult to understand hunger—unless you are hungry. I don't intend to deal with the physiology of hunger—nor with the debilitating effects of malnutrition on the productivity and progress of peoples. I will simply put in front of you a few simple facts. They are the sad measurements of hunger in their most meaningful terms.

Right now, today, in a period of unmatched prosperity and scientific advancement, nearly one-half of the world's population does not get enough to eat, or does not get enough of the proper food. More than 1.5 billion people in the world are either malnourished or actually starving.

This is a decade of crisis in which we must find ways to assure the world its supply of food for the years to come. One of the first obstacles we must overcome is the lack of awareness of the situation. Most Americans might complain about the prices of food, but they cannot question its availability. The world-wide hunger statistics are, nevertheless, frightening.

Population Explosion

The major cause of the food problem is the population explosion. Let's use the year 1 A.D. as the base for illustrating population growth. It took more than 1,600 years for the population on earth in the year 1 to double, from 250 to 500 million people. This is the span of time between the birth of Christ and the beginnings of English colonization of our Atlantic seaboard. But it took only 200 years to double again, and then less than 60 years to double once more. In 35 years, the 1965 population will double. In just 35 years, population will expand by numbers that previously took centuries to equal—and the geometric progression could move on. This presumes, of course, that so many people can be fed.

We can see why population is so often described in explosive terms. We have already reached the critical point, the year 1965 with its 3 billion-plus people. The present world population is projected to double by the year 2000 to more than 6 billion.

A fundamental fact of life today, which only the control of reproduction can modify, is that the girl babies who will produce the multiplying billions already exist. The factors of increased rate of survival and lower mortality rate, especially of girl babies to maturity and to child-bearing age, have led to the phenomenal explosion in the birthrate throughout the world.

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The problem is vastly complicated by the fact that the runaway population explosion is occurring primarily in the underdeveloped regions—those least prepared to meet the rising need for food!

By the year 2000, the combined population of Asia, Africa, the Near East, and Latin America will exceed 5 billion people, more than 80 percent of the world's population. Today, they comprise about 70 percent of the population.

In 35 years there will be far more people in Asia alone than there are in the whole world today, nearly 4 billion. Food production is far from keeping pace, and there is very little land suitable for new cropland development.

The highest rate in the population explosion is occurring in Latin America. There the population in 2000 will be nine times what it was in 1900. There will be land for expansion in Latin America, but only after serious, pervading problems have been solved.

Africa's population will have increased by half a billion during the 20th century. In Africa, there is room for new food crops, but, as in other parts of the world, many problems must be solved before the land can be used practically.

These cold, sobering measurements of population growth and the accompanying pressure for more food give us some perspective of the problem we face. Let us turn now to a consideration of the solution and some of the resources at our disposal.

The basic problem is human reproduction versus agricultural production. Human reproduction is outdistancing food production and must be brought under control while, at the same time, world food production must be increased. There are, really, two ways in which one can control birth; one is essentially motivation on a negative basis, depending upon mothers who do not want to see their children die. A more positive motivation is one which, in history, has shown a more enduring and significant effect. This is a decision not to have more children until a better life can be given them.

It does not propose to discuss, in any greater detail, the problems of population control. There are religious and personal ethical questions involved as well as the social mores of many areas. I do suggest, however, that it is increasingly possible to discuss the problems of family planning in a more rational and unemotional environment. In my opinion, this is an important step in the right direction.

It is, however, to the second step that we must address our attention as agriculturists and agri-business men. An unprecedented increase in worldwide food production must be pursued with all the knowledge and resources at our command.

What will happen if the problems of population growth and food production are not solved? History tells us some of the effects of famines—political turmoil, economic chaos, and a decline in human and spiritual values.

Some disturbing aspects of the social and political problems attending population pressures and food shortages are already quite evident. People like Sukarno and Nkrumah come and go in different parts of the world. (Nassar, Castro, and all the rest join in a cacophony of reckless abuse.) There are library burnings, street riots, and absurd political shifts in many of the developing nations.

It is well to remember that to many of the teeming millions in Asia and Africa things like freedom and even human dignity itself are only of academic interest. For them, the central problem is getting enough food to eat. In their case if totalitarianism can deliver the goods—satisfy their hunger—that's much more important to them than the loss of political liberties, something they have never known to any great extent anyway.

From earliest times, the pace of human progress has been associated with the development and productivity of the land. Land, until several hundred years ago, was the principal basis on which the progress of man and the wealth of nations were calculated. Exploration, wars, and all other major human activities were aimed at obtaining more land as the economic basis for growth.

Only a few centuries ago we recognized the importance of capital. The accumulation of capital and all the sophistication which goes with creating capital and making it a productive resource has paced the major part of the progress of western civilization during the last several centuries. In recent decades, technology has acquired a significance equal to that of land and capital as a major force carrying the human race forward in its material progress. Today, as a result of scientific achievements in many fields (including medicine, which is so directly related to the

accelerating growth of population), we have population putting a new kind and a new dimension of economic pressure on the land. In a very grim sense, we are returning to the point where land itself, as a limited productive resource, is assuming a position of major importance in human progress. Let us take a look at this limited resource, the agriculturally productive land on our planet.

Limited Resource: Agriculturally Productive Land

Not all of the earth's surface is suitable for agriculture. Most of the land surface of the earth has defects of such serious and fundamental nature as to eliminate any possibility whatever of its agricultural use. The nonproductive portion of the earth's surface consists of water, ice, desert, and rocks.

Other land areas are unsuitable for cropland, due to erosion, neglect, and too much or too little rainfall.

Let us measure the productive land surface by subtracting the unproductive parts. Of the earth's total land surface, roughly 33 billion acres, only about 3½ billion are arable, and in cultivation at the present time on this planet.

Let's take a minute to talk about the concept of a "planet." The planet earth still seems tremendously big to many people. The word "continent" also has a connotation of infinity or bigness. I remember in my geography lessons when we used to wonder why Australia was a continent when it looked like an island. We were told simply that it was too big to be an island. So the thought that a continent is large is also widespread.

What I am driving at is that we are at a point in our history where we can no longer delay meeting the problem of world hunger by rationalizing that the earth is big enough to support an infinite number of people. We have to change our mental attitudes and terms of reference and begin to realize that the part of the earth's surface with which we produce food must be thought of in finite terms of real estate and limited acres.

I believe that it is necessary now to become more accurately aware of the earth's limited resources for producing food. Let us look at the 3½ billion arable acres and the additional 2½ billion acres of potentially arable land. I shall go through a kind of cartographic "strip tease" and start with the base map of the world in mercator projection.

From this map, we are going to strip out areas and arrive at an understanding of just how limited this piece of real estate is for handling the problem of increased agricultural production.

More than 70 percent of the earth's global surface is water, the great salty oceans and seas that cover large parts of the globe. The oceans contribute only about 1 percent of our food supply. Even with future technical advances, we doubt that this portion of the planet will ever provide more than 1 percent of our food supply. For practical purposes we'll dismiss the oceans and seas from any further consideration and eliminate them from our map.

The south polar continent is frigid, supporting no plant life and only the most rudimentary biological species. Similarly, the more northerly latitudes across the top of the world in Canada, Alaska, Russia, and the Scandinavian countries which comprise the north polar ice caps and the vast stretches of tundra, offer small hope of any agricultural pursuit. There are a few migratory hunters, Eskimos, Laps, Indians, and others, who are dependent on wild animals, fish and semi-wild reindeer. They have established a kind of precarious tenure there; but it invites neither intensification nor expansion. So, for practical purposes, these polar regions—comprising about 4 percent of the earth's surface—must be completely written off.

Another area unsuitable for crop farming because of extremely cold temperatures, or because it is too rugged and barren of soil, is represented by the great mountain chains: the Rockies in North America and the Andes of South America, the Atlas, the Alps, and Carpathians, the Caucasians and the great wall of the Himalayas. These high mountain chains take up a surprising 18 percent of the land surface of the earth. This area also must be dismissed as being of no significant potential agricultural value.

Leaving the polar extremities of the earth, we find the sub-Arctic evergreen forests of spruch, pine, and larch which are important for lumber and pulp. With their podzolic soils and forbidding climate, however, these areas offer very little promise for successful farming. The development of hybrid seed corn and other genetic crop adaptations to the short growing season, together with some very heavy fertilization, has made a kind of slow inching progress

on the crop frontiers of this zone. But it can never be counted upon for more than small grudging concessions to be won and held at very high cost. Official estimates set the maximum potential arable land in this zone at about 10 percent or perhaps 320 million acres. Some part of that fraction is already being cropped or grazed, so any further advance or improvement depends on continued research discoveries and innovation. About 90 percent of the vast northern zone must, therefore, be dropped from practical consideration insofar as suitability for agriculture is concerned.

Deserts account for another 18-20 percent of the earth's land surface. They stretch across the continental land masses in both the north and south temperate zones, usually in the 20° to 40° latitudes and in the heart of the trade winds on the leeward side of the mountains. Their geographical position accounts for their dryness.

The heart of Australia, the Kalahari desert of South Africa, and the Atacama and Patagonian deserts of South America are the main deserts of the Southern Hemisphere. The Sonora in the southwestern United States and northern Mexico, the Sahara, the Arabian, and Thar in India, and Turkistan and the Gobi deserts of Asia visibly take up an important part of the northern hemisphere. Approximately 34 million acres of true desert soil (less than 1 percent of its total extent) can be made agriculturally productive by the proper use of water and fertilizer. These are the areas where great mountain-born rivers flow. Many other hundreds of millions of acres will not be economically available until sea water conversion becomes economically feasible. So let's cut that area out.

Next we have the savannah lands. The term "savannah" has no precise definition and really implies only that an area is covered by marsh, grass, scrub growth, and a few trees rather than by forests. It even more generally connotes alternate wet and dry seasons of varying intensity and length. Most of these large savannah regions lie in a poleward direction from the rain forest climate and frequently lie between them and the desert. The Llanos of Venezuela, the Campos of Brazil, the Sudan in the veldt of Africa, and the tropical grasslands of northern Australia, all have this characteristic location. In position, therefore, they are often between the constantly wet and the constantly dry climates and tend to be like each of them on their respective margins.

Not only are the savannah lands intermediate in position, but they are also intermediate and transitional in wind, temperature, rainfall, and vegetation characteristics.

These areas suffer a great excess of precipitation during the wet season which may be followed by a period in which there is no rainfall for many months. This drought desiccates the top soil, making it hard and impermeable. If a little rain should fall after the soil is packed, it can't seep downward, but rather it runs off or evaporates on the surface during the heat of the day. In some areas such as the Llanos and Goias of Brazil, this leaching process during the wet season forms a hardpan layer varying from a few inches to several feet in depth. The hardpan will not allow sufficient percolation or capillary movement of water, so the ground above it tends to be either waterlogged or excessively dry (one or the other) during much of the year.

The monsoon lands of southeast Asia provide enough water to support year-round irrigation in a system of double cropping, but the water now runs off, for the most part, into the sea, through such great rivers as the Salween of Burma and the Mekong of Laos, Cambodia and Viet Nam. As a result the land is used only for a single harvest of a single crop such as rice. The problem of doubling food production in the monsoonal land is not nearly so difficult as in some of the other types of savannah lands. If the rivers could be dammed and the waters thus made available for irrigation during the dry season, the essential precondition would be established for a much more universal system of double cropping with a corresponding increase in food output. Experts, keeping this in mind, place the potential agricultural savannah and monsoon lands at about 800 million acres. This represents about 20 percent of their total extent. The agricultural worth of the remaining 80 percent will continue to be limited to the hazardous and sporadic raising of livestock. Se we must remove from consideration that 80 percent of the savannah land.

Then there are the tropical rain forest lands. Much of the land within 10° of the equator is covered with a luxuriant and, at times, impenetrable forest of massive trees, tree ferns, and tangled vines. Vast sectors of Brazil's Amazon basin, Africa's Congo

basin, and most of Central America and Indonesia fall within this category. The continuous rainfall and unceasing high temperatures in these areas are responsible both for the agricultural possibilities that exist and also for the agricultural difficulties of these equatorial lands. Uniformly high temperatures and heavy precipitation throughout the year, with no marked dry season, are the two outstanding characteristics of the tropical rain forest. As a consequence, the typical soils of the rain forest (called laterites) are usually thoroughly leached of soluble mineral plant foods such as lime, potash, and phosphate. In spite of the heavy forest cover, organic matter is usually not abundant due to rapid decomposition and leaching on the surface. These soils must be classified as poor. They require very careful management if they are to become productive. They will not endure continuous cropping without frequent and heavy fertilization. Only the freshly deposited, unleached alluvial soils are highly productive.

Unfortunately, although the rain forest climate is excellent for plant growth, it is not favorable for the development of good agricultural soils. In the Far East, notably in India and Malaysia, most of the island areas are of this character; that is, laterite soils under tropical rainfall with climate highly suitable for agriculture. But the land is largely undeveloped and untenanted by man. Exceptions, such as Java, would seem to prove the capability of the environment for eventual high development but with enormous difficulty and cost. With the assumption that the great amounts of labor and capital required will be available and will be used, it is estimated that a billion acres and more of tropical rain forest might eventually be brought under cultivation.

Our world is now beginning to look rather strange. Finally, we must look for any remaining opportunities to subdue or reclaim temperate zone lands not already in agricultural use.

Most of the better lands in these zones are already under cultivation. The areas of population density as we see them in the world today do indeed coincide with the occurrence of productive soil types, the types which tend to be concentrated in the few major areas greatly favored by nature. The subcontinent of India, eastern mainland China, continental western Europe, and the United States east of the Rockies comprise the principal world concentrations of fertile soil. These are the original great regions of broad-leaved deciduous forests such as the oak, beech, and hickory regions of the eastern United States and of the tall and short grass prairies and steppes. They evolved as distinct vegetative types through the geologic ages, together with those underlying soil types which have the physical and chemical characteristics which add up to a single word—a magic word—fertility.

These are areas where climate has combined with soil to give the maximum conditions and suitability for agriculture as mankind has now learned to practice it. By and large, these areas in the north temperate zone are fully occupied. In many states in the United States, in India, in China, and in a number of countries of western Europe, the amount of total land which is actually under crop cultivation exceeds one-half of the total. When one considers the proportion of our best land already preempted by urbanization, by factories, airports, highways and railroads, or lakes and rivers, it is not remarkable that these long-settled and highly favored land areas of the north temperate zone and the northern subtropics are, for all practical purposes, fully occupied—even though only about half are in agricultural use.

Certain areas in the south temperate zone, notably in Uruguay, adjacent portions of northeast Argentina, Paraguay, and southern Brazil, some parts of east central Africa, and a little bit more of Queensland in Australia, offer the possibility of somewhat comparable development. In all, there may be as much as 240 million acres of additional good temperate zone land awaiting the plow, chiefly in the Southern Hemisphere. It may, therefore, be said that, in addition to the 3½ billion acres of land already under cultivation, we might be able to scratch out another 2 or 2½ billion acres, in all categories, which might be considered marginal or better for further agricultural use. This figure must be considered the potential maximum of what is physically there. Whether that potential can be realized through development is another matter. That, of course, is the challenge. One might say, "That's all there is: there ain't no more." And there isn't going to be any more. It has taken geologic ages to develop the earth's thin mantle of good soil. We may destroy it, as we have frequently—or we can conserve it, by wise and beneficial use. We cannot add much to it, and we cannot re-

place it once it is gone.

If all the presently arable land were formed into a single land area which found its latitudes from the separate places of its origin and its longitude from its mass, the continent of arable land would look like the one shown. All the rest of the planet is water or non-useful land from the standpoint of agricultural productivity. The productive "continent" would cover only 3 percent of the surface of the globe. The density of the population would be 400 people per square mile—about eight times that of the United States. In terms of crop soil it would provide only a little over one acre per person. The delightful phrase, "God's little green acre" is no longer a lyrical thought. It is a grim statistical measurement.

Taking these acres we have discussed and giving them a somewhat different treatment, we can show the "lifeline" of the world. Present arable land is less than 3 percent, potential arable land is another 2 percent, and unproductive land is 24 percent. The rest is ocean at 71 percent. Much of the potentially arable land awaiting development presents enormous difficulties before it can be subdued. Moreover, with the tropical laterite soils, for example, there is much that we don't yet know. It will have to be established by costly and time-consuming research, or even more costly trial and error. Only by these methods can we learn how these soils can best be managed and developed for maximum crop yields.

All the potential additional cropland would represent a 70 percent increase in cropland area at most, with perhaps no more than 50 percent increase in productive potential, since these lands are basically less productive than the lands already in use. In the underdeveloped regions, this means doubling or even trebling production per acre, and this will indeed require enormous strides in production technology. Some indeterminant part of these anticipated additions of cropland may already be included in man's present food resource base, either as meadows, crops, or grazing for livestock. Under the most optimistic assumptions, approximately two-thirds of the vital future food production increase will have to come from improved yields on land already under cultivation.

A most important element in bringing about the needed "agrarian revolution" will be modernizing and mechanizing primitive agricultural methods the world over. To this statement it is necessary to add one very important thought: One does not put Missouri-type mechanization into a Turkish agricultural situation or in the Congo. One must include adaptive research and adaptive equipment engineering.

Even the most sensational breakthroughs in science directly related to the problem of increased food production will not, by themselves, solve the problem in the limited time that we have available.

It *can* be solved, but only by a successful effort in total, "packaged" terms by

Fertilizer, Pest and Disease Control, Genetic Crop Improvement, Farm Machinery and Tools, Farmer Cooperatives, Farm Credits, Capital Investment.

Education, Technological Training, Roads and Communication, Distribution, Marketing Facilities, Governmental Assistance, Political Stability.

I would like to conclude with a few thoughts on what these things imply for the United States and for Missouri agriculture, agricultural scientists of Missouri, and agri-business in Missouri.

The first question which many people ask is whether or not the United States must, or can, make up the food deficits in the rest of the world. I think the answer in the long run is clearly "no." I don't believe that our land and other economic resources are equal to the staggering long-range task of feeding the world. Viewed long range, the developing nations of the world must feed themselves. This thought is certainly not original with me. It seems fairly evident that this is the decision which our government has reached. The food assistance programs and other technical assistance which we are sending abroad are increasingly based on the concept that the recipient nations will be required to make greater efforts to help themselves.

For the next several years, however, we must give a "yes" answer to the question of U.S. exports of food. It seems quite apparent that food will be an

instrument of U.S. foreign policy. We are going to have to send large quantities of grains and other food resources abroad to help fight hunger and political instability for at least several years. In order to do this, and at the same time meet our domestic food requirements, I believe we are entering a new agricultural era in the United States. It is generally difficult to recognize turning points in history except from the vantage point of elapsed years. I predict, however, that we will look back on the years 1966, '67, and '68 as a true turning point in American agriculture. We are passing out of an era of surpluses and over-supply to an era where all our agricultural resources will be taxed to the limit to supply food needed at home and abroad.

This places a real problem squarely in the lap of Missouri and her neighboring states. The Midwestern and Great Plains states of the United States, together with some parts of the adjoining Canadian provinces, form the greatest contiguous land mass in the world today of fertile soil—under favorable climatic conditions—and with highly developed agricultural and management skills. This area is truly the world's greatest "bread basket." Its resources must be unleashed and allowed to produce to the fullest extent possible.

It also seems certain that agricultural scientists in our colleges, the various branches of the Extension Service, and even in industry will be called upon to upgrade the technology and agricultural savvy in the production of crops, livestock, and poultry around the world.

Industry will be needed also to help solve the world food problem. It will be called upon to make investments of time, money, and production facilities and technology in foreign countries. The feed industry, the fertilizer industry, the seed industry, the agricultural chemical industry, and the farm equipment manufacturers will play a key role in fighting world hunger.

To sum up this picture:
The World is hungry.
It's going to get hungrier.

The factors creating this crisis are inescapable: it is a function of the population explosion and limited land.

Agriculture must be made more productive, and kept in balance with industry. The vehicle for doing this is the organization and application of technology, as it has evolved in capitalized society. The productivity of American agriculture is the envy of the world; the American farmer is our most believable hero—on the world scene. This highly productive man has become capitalized himself with the benefits of science, technology, and industry. He is therefore a most sensitive element in the success of our country. Thoughtless manipulation can destroy him. He needs more and better understanding in his agri-business relationship.

We recognize that the environment which made the American farmer productive is not easily exported or duplicated elsewhere, but the effort must be made.

It will require the commitment of private industry in support of agricultural development programs abroad. And it will require, finally, a new awakening to the moral implications in human hunger, dynamic agriculture, and our domestic and foreign programs.

We cannot look for "'instant agriculture" to bail out half-baked plans or spur-of-the-moment programs. We can rely on dynamic agribusiness systems if given the incentive to respond and the freedom to work.

We can engineer a new age in agriculture, so long as we don't become so involved in other things as to lose our strong tie to the soil—the root source of man's well-being.

And despite all the difficulties, I don't think man will lose that tie, for he often loses his perspective, but never his instinct.

World Population

REX R. CAMPBELL*

Many of you have read the January 8, 1967, headlines "'Output of Food Down 4% in Poor Countries" in the *St. Louis Post-Dispatch.* The article quoted William S. Garid, head of the Agency for International Development (A.I.D.) to the effect that there is serious doubt "that advanced nations will be able to continue making up food shortages for the developing countries." He stated that "total food production on a per capita basis dropped last year by about 2 percent." While the 1965-66 time period was unusual in the severity of adverse climatic conditions, the statement is startling.

Another set of statistics which have been widely publicized are those which show a decline in feed grain carry-over in the United States from 85 million tons in 1960 to about 43 million tons this year. This decline has come about in large part because of increases in export shipments to many of the developing countries.

A third factor which again I am sure you have heard is the so-called "population explosion," or perhaps the term "population avalanche" is a better one. Figures have been published to indicate that people were multiplying faster than the proverbial rabbits.

The fourth item I would like to introduce is the often "cussed" and discussed subject of family planning, birth control, contraception or whatever you prefer to call it. Here we encounter such subjects as "the pill," intra-uterine devices (IUDs), rhythm method, and others.

I would like to take three subjects: Food supplies, population growth, and family planning, and review the present situation and take a look toward the future. In particular, I will limit myself to the latter two: population growth and family planning.

Let me do this by attempting to answer a few questions. What is the present situation in terms of population growth? Where are the trouble spots? What about future growth? What are the major factors likely to influence the future trends in population?

The answers to these questions are of vital concern to all of us, both as agriculturists and as United States citizens. In the future, population growth will influence the per-capita availability of the world's food supply; and it will strongly influence the political stability, and the economic and social welfare of many of the world's people. Clearly, as citizens of one of the richest nations in the world, we have the moral obligation to help these less fortunate persons. From a more selfish viewpoint, it is good business for the United States to see that these persons develop their economic resources to fill their basic needs because this will often result in greater consumption of American agricultural and industrial products. Neither of these viewpoints may be fulfilled if the growth in numbers of people continues for very long as it is today.

What is the Present Situation?

If one were to plot the growth of the world's population as a line, it would assume the shape of a compound interest curve—increasing at an increasing rate. Let me hasten to add that I do not assume that it is inevitable that this continue indefinitely. This sudden spurt in the 20th century has resulted from a control of the previously uncontrolled death rates of mankind. Man's life throughout history has been characterized as short and brutish. However, this has begun to change. A measure of death control, at least in earlier years of life, is now possible.

Death is only one-half of the vital processes. The other is birth. It was essential in the earlier times, if mankind was to survive, that the birth rates be at least as correspondingly high as the death rates. However, the problem is that in most countries the birth rates have not declined as rapidly as the death rates, if at all. In the future, man has but two choices: the birth rates must be reduced or the death rates must rise at some future time as the resources become in-

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creasingly limited. The choice betweeen the two will be made by "nature" if mankind does not. And now the technology and knowledge for birth control is becoming available, but more about this later.

In the summer of 1966, the population of the world had passed the 3.3 billion mark. According to the Population Reference Bureau, this represents an increase of 65 million in one year or 180,000 a day, or about 24 days to add more people to the world than are now residing in Missouri. It would take a mere three years to add the equivalent of the United States population.

The present world's rate of population growth is over 2 percent per year. It is currently estimated that the population will double in about 35 years. It took almost twice this long, 60 years, for the doubling just completed, and increasing lengths of time before that. Starting with the time of Christ, it took 1600 years for the population to double (0—1600 A.D.)

The rates of growth are very uneven from country to country. There are some which are losing or barely holding their own in numbers (Ireland) while others are increasing at a rate which will double their population in less than 20 years (Colombia).

The Trouble Spots

A fortunate one-third of the human race has or is approaching a relative balance between births and deaths. For Europe, North America, Oceania, Japan and a few other countries, the rate of growth is about 1 percent per year. For the remaining two-thirds, the growth rate is over 2 percent and has been increasing for the past three decades. Here, the birth rates remain very high, death rates moderate but declining. Life expectance at birth is about 40 to 50 years as compared to the 70 years of the first group. The high birth rates and short life expectance are only a part of a syndrome which is found in many of these countries. Often the population is relatively illiterate, and primarily agricultural in occupation. The economics, political and many social institutions are relatively "undeveloped." Or to use the current euphemism, these are the "developing" countries. They are found largely in Africa, Latin America, and Asia. Most of these rapidly growing countries are located in the world and, with the exception of Latin America, are peopled by persons of non-European origin or as Mainland China has stated: "colored people" vs. the white oppressors.

Major Factors Influencing Trends in Population

Obviously, the major factors affecting population are birth and death rates and immigration. In the present political climate and in consideration of the numbers of persons involved in most countries, immigration can be disregarded as a factor of major importance in population trends. It is true that for a few relatively small countries such as Ireland and the Netherlands, out-migration may be important and perhaps for such countries as Australia and New Zealand in-migration is important. These are the exceptions rather than the usual.

The dramatic decline of the death rates in many countries since about World War II has been one of the most important changes in the history of mankind. This decline is continuing in many of the "developing" countries until today the death rates are approaching, or in a few cases due to abnormal age distribution, the death rates are even lower than in the developed countries. Africa, in particular, still has relatively high death rates. The variation in death rates from a high of 40 deaths per year per 1000 population to 3 in the Panama Canal Zone. Most of the developed countries have rates of 10 or slightly under. However, the rates for the developed counties vary widely both from variations in actual rates, and also from wide variations in the age distribution.

The variation in birth rates is equally wide. In some of the developed countries, the rates have declined until they are at or near the level needed to only maintain the population.

Family Planning

There are two ways of meeting the food needs of the increasing world's population. One is to make major additions to the world food supply and distribution systems. The other is to stop or reduce the increase in number of people. A generally accepted solution is a combination of these two—an increase in food supply and a decrease in the rate of increase of population. If the latter is to occur, it means that the vast majority of the world's population must adopt the idea and techniques of family planning. Today the idea of family planning is widely known and accepted

in the developed countries, but as I noted in my discussion of birth rates, these have not been adopted in most of the remainder of the world. This lack of use results from a number of factors: economic, cultural-religious and physical.

In a few moments, I will briefly review those, however, first let me discuss the present state of technology concerning family planning.

Until a few years ago, the major contraceptive techniques were relatively expensive, less reliable and required considerable care and planning by the couple. With the advent of "the pill" the situation changed radically. However, oral contraceptives, with their need to be taken 20 days a month under medical supervision and relatively high cost, have been limited primarily to the educated middle-class of the world. It is estimated that about 8 to 10 million women are now using such contraceptives. This is out of a total of 500 to 600 million women of productive ages.

The second major contraceptive device to appear, or rather reappear in recent years, is the intra-uterine device (IUD). These loops and spirals were greeted by wide acclaim and offered considerable hope as a means of birth control. Here was a device that was cheap to manufacture and easy to use. It was and is being adopted in large numbers in countries all over the world. It has had remarkable records of acceptance in such countries as Taiwan, South Korea, Tunisia and India. Recently a cloud has appeared on the horizon of this bright future. This is research which showed that only 40 to 60 percent of the women retained the devices after two years. In part, this loss was voluntary, however, the need for skilled insertion and medical follow-up creates serious obstacles before the IUDs can be used by large numbers of people in the developing countries.

Other techniques are being developed and may be available in future years. My point here is to simply note that we do not have any single or combination of devices which can meet all or perhaps even a majority of the world's need for such items. There also remains a critical need for more basic research into the fundamental chemistry and biology of human reproduction.

Factors Influencing Birth Rates

1. Age structure. In many of the developing nations the majority of the people are under the age of 18. This may have a tremendous effect and potential effect on the crude birth rates. In contrast to many of the European countries, a vast majority of the females are either in or under the prime ages of human reproduction (18—30). Even if the women in the developing countries had the same number of children as those in the United States, the rate of population increase in these countries would be much higher because of the disproportionate number of women in the child-bearing ages. In many of these developing countries, large future increases in population are insured by the very large potentials which are already born. For example, in Mexico, the number of women in the age group 15 through 44 will increase by 90 percent—almost double—in the 20 years between 1960 and 1980. Barring what can only be termed a catastrophic decline in birth rates, the population in Mexico will continue to rapidly increase for a comparatively long period of time.

2. Reduction in mortality. The number of infants and children that die before reaching adulthood is still comparatively high. This is and will be reduced substantially further in the near future. This reduction will permit a larger proportion of the population to reach the reproductive years. It will have the net effect of raising the crude birth rate.

3. Cultural-religious factors. The term cultural-religious is used here because it is impossible to separate the purely religious beliefs from other beliefs outside of religion. The relationship between the cultural-religious factors and fertility are extremely complex. Obviously, the factors are very influential on fertility and not so obvious is the fact that these factors are very difficult and slow to change. Examples of some less obvious relationships and influences are in the kinship structure, the proportion of the population marrying, the frequency of intercourse, taboos against intercourse during certain religious holidays, and for a period after childbirth.

An example of the influence of a religion can be found in the Moslem countries. The Moslem religion and culture encourage high fertility because there is

- an injunction to marry and multiply;

- the belief that Allah will provide for all souls He permits to come into the world;
- a general resistance to change;
- an emphasis on sexuality;
- subordination of women (birth education);
- marriage of women is almost universal;
- age of marriage of women is low;
- institutions which favor early remarriage of widows and divorcees;
- no celibate priesthood; and
- abortion, but not contraception, is strictly forbidden.

How quickly the tremendous social and economic upheavals which are now occuring in the developing countries will change these factors is unknown. Certainly the rising expectation and levels of living, the rising educational levels, and rapid urbanization and in some countries, industrialization, will influence these factors. I would suggest that it will take a period of several generations, perhaps 50 to 100 years, to make the really major changes. This, however, is speculation; it may occur more rapidly.

4. Knowledge and availability of contraceptive methods and devices. The majority of the people in the developing countries are uneducated and often isolated in a communications sense. Many of them have little knowledge of the possibilities of family planning. However, some recent studies have revealed very encouraging evidence, that many of these people desire to have fewer children than they are now having. Some of the recent family planning programs in Taiwan, South Korea, Hong Kong and Singapore have met remarkable success. In just the space of the recent five years, many governments have started or are starting family planning programs. Even the changes in the United States government's actions and policies have been very significant.

Future Trends

Demographers are in considerable disagreement as to the future. Bogue has taken the extremely optimistic position that fertility would be reduced to near zero by the year 2000. The other extreme is that population will increase at an increasing rate and will more than double by the year 2000. Between these two extremes, it is evident that the population will continue to increase for a long period of time. In addition, it can be expected that the following will occur:

1. Growth rates will increase in the next one to two decades because:
   - a continued reduction in the death rates is expected, especially in such areas as Africa and South Asia; and
   - as levels of nutrition and health increase, a rise in fertility occurs because the very low levels in some areas today are inhibiting maximum fertility.

2. A slow decline in birth rates. The rates of decline will increase as the methods of and devices for contraception are improved and as the educational and economic levels of the various peoples rise. This decline will come about very slowly in such countries as India and Mainland China where the educational, communicational, and other social and economic institutions are less developed. It is and will occur much more rapidly in countries where the economic and social institutions are more advanced, such as in Taiwan, South Korea.

3. Within a country, birth rates will decline more rapidly in urban areas and among the upper social classes. Thus, the introduction of family planning in many areas may be accepted quickly by this relatively small group. We should not be misled, however; the adoption and accompanying decline in fertility will be unfortunately slow.

The United Nation's "middle projections" are those which "fit" my preferences and are those used by most demographers.

Let me consider some very unattractive alternatives to these trends. If population numbers and food supply are not brought into a closer balance, it is probable that political and economic instability will increase. It would be easy to get into a self-consuming cycle where the low levels of per-capita food

and economic welfare contribute to political and economic instability which in turn would handicap or inhibit the resource development.

If food and other resources are to be provided in adequate amounts to the world's peoples in the coming decades, the world's and the United States' agriculture and other industries are faced with a challenge of unprecedented proportions. We have no choice but to face and meet the challenge; the alternatives are not acceptable.

Some Alternative Solutions for Balancing World Production and Needs

LAWRENCE WITT*

Much of today's discussion of population and food supply paints a dire picture of the world of 1980 and beyond. Were Reverend Malthus to return, he would be far more comfortable today, intellectually, than during most of the past 150 years. Why? Or more properly, why are we disinheriting 100 years of agricultural progress in this and other advanced countries, and returning to the dismal economics of Malthus and Ricardo? Several explanations may be suggested.

First, we are gradually becoming aware of the differences between the *reconstruction* of a war-torn Europe and Japan and the *development* of a traditional society with per capita incomes of $200 and less. The long-term investments in human capital, research and other social overhead items require much more time and patience than many have been prepared to give. With the lessening of expectations our frustrations turn into pessimism.

Second, we are impressed by the rise in the net rate of population increase during the past ten years. Public health measures that lower the death rates are easier and cheaper to adopt than measures to increase the production of food. Thus, projecting on this basis, we see population increases outrunning the increases in food supply.

Third, those who work with the data may have been biased toward pessimistic data selection by the popular concern with food supplies. In any case the data are notoriously inaccurate. The selection of this set or that set of figures can make a difference of several percentage points. Since the original data may have errors of 10 percent and more, the choice of sets of data does not make much difference in the accuracy. But in the final reckoning, a change of 1 or 2 percent makes the difference between an improved or worsening per capita situation.

Fourth, we accept too fully the idea that the marginal productivity of labor in agriculture is low, or even zero. Thus, a larger population with more people working in agriculture is not expected to yield greater production. Yet the facts seem to be otherwise in many countries. Most developing nations are increasing food production about as fast as population; most of them more rapidly than the U.S. has ever done.

The fifth possible reason for our pessimism is that the facts now presented to us are accurate, and that despite our increased production and export efforts, the developing world *is* falling behind in its population food supply balance. Our pessimism may be warranted.

I will comment a bit on our efforts to change the basic elements of the population-food supply balance, but my principal task this afternoon is to examine alternative points of equilibrium with possible different sets of policies. Let us examine the elements of policy that appear to be relevant. Both the substantive character and the value issues of these elements need to be considered, on a stateside basis, in the framework of the other country, and in international relations. Obviously time does not permit a full elaboration of all these items.

Past Food Export Policies

One of the policy items is to continue recent programs.

During most of our history, American policy has emphasized commercial agricultural exports. During recent decades, we have provided food for victims of disaster, including war, and more recently, concessional sales and grants under a massive P.L. 480 program. The justifications for major export pro-

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grams have been complex and unclear. Cited objectives include expansion of commercial sales, stimulation of economic development, raising of nutritional levels, improvement of social welfare, implementation of foreign policy goals, and disposal of surpluses. Now, the same programs are cited as a means of expanding food production overseas, and a way to meet the food needs of rapidly rising populations. It is doubtful that any program can attain all of these objectives; nor can policy be redirected simply by coining a new name.

General beliefs about the accomplishments of food programs are out of line with what is actually being done. For example, many people probably would be surprised to know that our recent large food shipments to India are being sold within India to people with rupees to spend; they do not provide free food for the low-income 10 to 15 percent of the population. True, the AID sponsored donation programs are directed toward the more poorly fed sectors of the population, but they are small, comparatively. Since much political support for the food aid programs stems from value positions against hunger and malnutrition, it appears that accomplishments are out of line with values. If this is true, we badly need revision of programs, especially of the USDA administered program, through hard thinking about ends that are both desirable and attainable, followed by careful construction of feasible programs.

Population Controls

For the long run, population must be controlled. If the world can feed 3 billion people in 1965, 6 billion in the year 2000 and even 12 billion in the year 2035, surely 24 billion is too much for 100 years hence. Since social innovations usually develop slowly, partly because of time lags in reaching the millions of families who must participate, *now* is not too soon to step boldly into family planning. In the area of human reproduction, a good case can be made that the process is started. Dr. Donald Bogue, sociologist, at the University of Chicago, argues that a "vital" revolution is underway. Already hundreds of thousands have not been born. He cites dramatic evidence from Korea and elsewhere suggesting that the decline in the birth rate already has surpassed the decline in the death rate, leading to more modest rates of population growth. Several reasons are cited. One is that between 1945 and 1960 the death rate was reduced by half of the difference between developing and advanced societies. Thus, this impact of modern medicine on the death rate is largely behind us. The major reason for less pessimism for the future, however, is the rapid and widespread use of birth control devices, and the almost universal desire of both rural and urban families to use contraception once they have three children, especially if one is a male. He claims that word-of-mouth transmission of information is almost as effective in rural areas as in cities. Dr. Bogue argues that the 1970 census already will reflect this "vital" revolution in the statistics on children under five years of age. He bases these conclusions mainly on Korean and Taiwanese experiences, but argues that evidence from India, Pakistan, Colombia and Chile point in the same direction.

Population control is not a policy alternative: it is a policy imperative. The only question is how soon and how much can be accomplished.

Food Needs and Demand

Projections of national, regional, and world food needs indicate requirements so high as to call for every available effort. Such projections appear to have a simple, logical base. On the one side are biological requirements based on population projections. On the other side are food elements based on production estimates. In extension work in public policy, my recommendation is not to take such data too seriously. Probably at no time in world history have food needs not been substantially greater than actual consumption. The per capita gap probably is smaller in our generation than ever before.

Somewhat more reliance may be placed on estimates of demand. Still, demand for food in a particular country can be estimated with some precision only in terms of local currency, but this assumes that the deficiency in foreign exchange will be corrected. Nearly all macro-economic projections indicate increasing foreign exchange deficits. Thus, an increase in the local demand for food will not automatically increase the world demand for food. Account must be taken of the international flow of loans, development aid, and commodity assistance, as well as the import priorities of the developing nations.

Some Value Problems

Real starvation exists only in isolated instances, and programs to deal with partial starvation or serious malnutrition represent only a small fraction of the world's total food export and agricultural development programs. The really large current problem is to improve the level of nutrition. If we start with food needs, place a high ethical value on the attainment of adequate nutrition, and then determine that the developed countries will contribute resources to that end, we quickly face many problems.

One problem relates to values associated with different levels of nutrition. Levels of minimum nutrition vary depending upon the standard used. A minimum which permits reproduction is surprisingly low. A nutritionally deficient diet will still permit productive work, though the hours and rate of activity may be limited. A diet deficient in certain food elements will still produce children heavier and taller than their parents; something more than this is needed to provide a "joyous living." Toward which of these levels should "requirements" be geared? Neither nutritional science nor agricultural economics provides the answer; yet as a people and as a government, we are making decisions concerning these levels.

Another implicit value judgment is that all people should consume at or above the minimum level. Some people eat poorly even when they have income to purchase an adequate diet. Many of these people do so because they do not realize their diet is inadequate; some know how to improve their diet but choose not to do so. Others eat more than they should. Yet calculations of food needs assume that all will and should consume the minimum diet.

A third major value assumption is that necessary steps will be taken to make adequate diets possible. The logistics and operation of such programs are costly. Nutritional studies indicate that the preschool child, especially after weaning, is the most poorly nourished person in most developing countries. It is difficult to develop programs for one child per family. To feed other poorly nourished groups requires transport and distribution facilities to reach isolated areas, emergency distribution after an earthquake or other natural disasters, or a plan for distributing food to the low-income 5 or 10 percent of the population who live on the fringes of society. Such programs are complex and costly.

Various studies verify the wide prevalence of certain deficiencies related to inadequate diets, particularly the absence of certain amino acids deficiencies correctable by greater consumption of beans, lentils, and animal proteins. Some calorie deficiencies appear, but mineral and vitamin deficiencies are frequent.

The real problem is the interrelation of values —how far are we willing to go toward better nutrition? At home? Overseas? Should we convert feed grains to animal protein for export abroad? Should we support programs overseas which convert exported feed grains into animal protein, which then is donated to malnourished groups? Either technique converts resources toward a more positive nutrition program. But the costs of such conversions are substantial. Do we hold a sufficiently strong value in favor of better nutrition to warrant incurring these additional national expenditures? Or, are we interested in nutrition only as it supports grain exports and hence prices at politically acceptable levels?

Logical analysis of nutritional facts and choices, assumed as the single goal of concessional exports, would lead to substantial changes in present programs. On this basis, much of our present within-country sales are to the wrong people, nutritionally speaking. Also, we are exporting too much wheat and too little animal-type protein, and the benefits overseas go largely to people not suffering from severe malnutrition. But more meat exports, within the present program, will benefit mainly the American farmer and the already well-nourished, high-income 15 percent abroad.

A real nutritional program is expensive. The food part of the costs can be held down by using synthetic vitamins and mineral supplements. Extravagant claims are sometimes made for fish meal. Vegetable derived, meat-type proteins can contribute. Expanded overseas production of animal proteins usually is cheaper, particularly when the costs of transportation and local distribution are included. Distribution to the disadvantaged individuals and groups suffering most severely from malnutrition is likely to cost more than the food itself. We have not really thought through the costs of a significant improvement in the level of nutrition around the world, how to minimize such costs, and how to maximize the

values achieved.

At this point, then, two world food problems cry for attention. The first stems from the population explosion; the second from the values attached to improved nutrition. Policies to mitigate these two problems involve one or more of the following: (1) grants and concessional sales such as those under P.L. 480, (2) an increase in exports by developing countries which permits a rise in commerical imports, and (3) expansion in food production within the developing nations. What contributions can each of these policies make? I will deal mainly with the first of these, and briefly with the second, although only the third provides a long-term solution.

Nutrition and P.L. 480

Most of the present concessional sales programs of P.L. 480 would need to be replaced or drastically revised and donation programs vastly expanded if nutrition were emphasized. A tremendous increase in personnel and changes in programming would be required to insure that the food did go to the low-income classes and most poorly nourished individuals. Since the bulk of the programs would be in underdeveloped countries, personnel problems would be substantial. Competition for capable local talent would soon raise questions about what is more important to Brazil, or to Colombia, or to Pakistan—better nutrition now or improved rates of development and better government administration, with subsequent improvement in nutrition. And these questions, too, the United States must consider.

I would like to summarize the effects of P.L. 480 upon nutrition in six points. I shall make each point and then discuss it briefly.

1. Concessional exports have led to a better *international* distribution of food than otherwise would have been possible. India is eating better today than would have been possible with free markets and the probable amount of international loans. T. W. Schultz implies that a better program would have been lower grain prices and freer trade, supplemented with larger foreign loans. But better nutrition requires more than an efficient allocation of resources; it requires a redistribution of income nationally and internationally. The concessional sales program is putting more grain into India than any other politically conceivable program, in my opinion.

2. Low-income consumers have benefited to a degree from concessional sales because cereals are cheaper than they otherwise would have been. With cereal from abroad in India, Pakistan, Turkey, Brazil, bread prices are less than they would have been.

3. Small-scale donations may function effectively to improve nutrition, but donations cannot solve the total nutritional problem. Large-scale programs imply serious conflict in the use of scarce manpower and infer high distribution costs.

4. Some low-income groups have benefited from food donations, but the real contribution of these donations to human and economic development has not been evaluated. How much more work can a man do because he has 10 to 15 percent more bread or rice? What are the human and economic development impacts of school lunch programs, ten years later? Hypotheses and theories are common; evidence is not.

5. Desirable social and humanitarian goals are associated with the AID administered donation program to a far greater degree than the much larger USDA administered program. Even so, actual results are unclear, and the donation program appears to be only partially successful. As an example, the commodities provided in school lunches may not balance the diet of the children participating.

6. The sense of social purpose among AID Food for Peace officers overseas is attenuated greatly by efforts to provide economic development or market development justifications for their programs. Unfortunately, this down-playing of social values is all too common among U.S. representatives abroad, perhaps because a mistaken economic view is too dominant in Congressional political circles.

Population Growth, Economic Development and P.L. 480

Let us turn now to the concessional sales part of P.L. 480, representing four-fifths of the total.

A barrage of press releases and popular articles attests to the interest in the ten-year, $15 billion Food for Peace program. What international social objectives have been achieved? It is argued that these shipments have filled an appreciable part of the food gap in developing nations. But if this true for the past, what of the future? Also, it is argued that food shipments contribute to economic development. If so, how? Again, let me make my points in rapid fashion.

1. Concessional food shipments can save foreign exchange and enable a country to import more tools of development. The USDA understandably cannot advertise this contribution, since it is charged with making agreements that prevent such "diversion." To accept exchange saving as a significant contribution is to admit significant failure in administration. Nonetheless, such "leakages" appear to have been a major development contribution in a number of countries, notably Israel and Brazil. Actually, if we accept the idea of food as an aid to development as a legitimate goal, such "leakages" make food a better substitute for dollars, thus decreasing U.S. costs of a particular rate of development, or permitting a higher rate of development.

2. The contribution of concessional imports to food supplies has been marginal in most countries. Marginal changes are important, but the usual projections of population increases require large additions to food supplies. The United States cannot produce and transport the physical volumes required. We cannot feed the world, or even a significant part of it. The responsibilities that we accept must be realistic and feasible.

3. In some cases, concessional food shipments have prevented uneconomic use of resources. For example, Brazil and Colombia have curtailed rather than expanded their production of high-cost wheat.

4. Farmers in some countries have been injured by lower prices than would otherwise have prevailed. In some countries, governmental price programs have protected them from adverse effects.

Any positive development impact stemming from added food imports must be balanced off by whatever negative effect the food imports have on the domestic agriculture of the receiving countries, and on its suppliers, if an importer. An apologist for the program might deny any adverse effect on agriculture, yet argue the benefits to local consumers through lower prices, as U.S. supplies are marketed. We cannot have it both ways unless we are prepared to argue, also, that no significant group of farmers in developing countries respond to price.

5. The lag in priority of investment in the agricultural sector in a significant number of countries is attributable to the relative ease of obtaining P.L. 480 supplies. This argument focuses more on the attitudes of high officials, leading to a longer persistence of an "industry first" outlook, despite declining death rates and rapid rises in population. Some effect of this disinterest in agriculture is seen in modest public investments in agriculture, and relatively low caliber local personnel. In my opinion, one of our major tasks in the next several years, a process already started, is to convince other nations that we can contribute only a little in physical food supplies, and that they, perhaps with technical help from us, must make the major contribution in achieving adequate per capita food supplies.

6. The contribution of local currency (derived from concessional sales) to economic development is nearly zero. In a few countries, the U.S. does have some leverage or influence, either because the country lacks knowledge of monetary principles, or because close political ties persuade them to go along with some bureaucratic juggling of funds. Concessional wheat imports can make a higher rate of development effort possible. However, U.S. owned local currency is not a necessary asset for this process. Moreover, wheat is not likely to take more than 20 to 30 percent of the new expenditures. Other food and nonfood items must be provided to absorb the remaining added purchasing power.

7. Food programs have been an instrument of foreign policy. Unfortunately, the pressure to export has been so great in the past as to reduce the bargaining position of our overseas representatives. Food export policy has been separated from agricultural policy abroad and has had little relation to over-all

AID objectives. I am not convinced that recent changes in instructions are operational.

8. Finally, of overwhelming importance, even if we agree that concessional sales represent more than a surplus disposal program, it is now clear that they were only a temporizing solution to the problems stemming from rapid population growth.

Exports and Imports

The second major alternative in solving the world food and nutritional problems is an increase in developing countries' exports to permit an increase in food imports. Yet, population increases threaten to reduce future exportable surpluses. To save time let me state my conclusions about the role of trade in solving food problems without the argument.

- The less developed countries need to expand the exports of natural resource based commodities. With the exceptions of a few countries with extensive petroleum and mineral resources, farm products should be exported in larger quantities. To do so, increased agricultural productivity and output are vital.

- The developed countries have many tariff and trade barriers which limit their imports of farm products from developing countries, and also discriminate against the partial processing of major export items.

- The import capacity of developed countries is restricted by a great variety of subsidies of production. These efforts make "aid not trade" an essential element of the foreign policy of nearly all the developed countries for a long time to come. Aid is not a good substitute for trade.

- Any developed country's program to expand agricultural production should be measured against the cost of imports minus a share of their foreign aid expenditures. The results often will indicate that a developed country should import certain farm products.

- More trade as such contributes little to improved nutrition. True, an improvement in income can advance nutrition, but most changes in nutrition depend on country level programs.

- Empirical studies of comparative advantage are sorely needed as guides to policy. Such studies should incorporate transportation and distribution costs, not abstract from them. Development plans tend to be constructed for a closed economy, in part because there is little basis for identifying tomorrow's export products. The absence of this information means that we move to the third major alternative—food production—in a framework much too close to self-sufficiency.

Summary

Clearly, most of the food for the augmented world population must be produced by the people in their own countries. Even tripling of world trade in food products would not suffice to contradict this statement. Similarly, nutrition will be advanced most rapidly by country and local programs to fortify existing foods, to educate the homemaker on better diets, and to provide food supplements to those most desperately in need of them. The bulk of the world's population-food supply problem, then, resolves into a within-country effort to control population growth and to stimulate food output.

The pressure of population and rising incomes upon food supplies is increasing. International food and agricultural efforts have been influenced by the existence of U.S. surpluses; even now, with sharper recognition of the problem, the orientation and structure of past activities persist.

U.S. and advanced countries' efforts to meet the world's nutrition problems through exports can have only a marginal impact, and perhaps a demonstration effect. Any concessional exports should be used far more effectively for values with highest priority. A substantial change in programs is necessary, with more modest but attainable goals.

The food problems posed by the population explosion can be solved. They will be solved only by a combination of positive checks on population growth and a substantial expansion in agricultural production in the countries where population is increasing. There will be no greater agricultural challenge in your lifetime and mine.

Prospects for Increasing World Food Production

EMMETT L. PINNELL*

Famine and hunger are an old story to the human race. In the last thirty years of the 19th century twenty million people died of famine in India. During the whole of the last century, one-hundred million individuals starved to death in China. Since World War II, widespread famine has been virtually eliminated in the world by food shipments from the United States and other developed countries. But hunger has not been eliminated; in fact it may be on the increase. Its components are undernutrition from insufficient food and malnutrition from a deficiency of protein, vitamins, or minerals. In 1950, Lord Boyd-Orr, the first Director of FAO, stated that a lifetime of malnutrition and actual hunger is the lot of at least two-thirds of mankind. Later estimates place the ill-fed people at one-half of the world's population. It is really academic as to whether the hunger fraction is one-half or two-thirds; the real point today is that there is a wide and growing gap between the nutritional levels of the developed countries of North America, Europe, Oceania, and Japan and the nutritional levels of the less developed nations of Central and South America, Africa, and Asia. In the latter countries, mortality rates of infants and preschool age children are much higher and the principal causes of death are the diseases that result from a combination of infection and malnutrition. Undernutrition of adults undoubtedly retards economic progress.

For more than 10 years, the United States has been shipping surplus food to the developing nations. The amount is now increasing. With the recent disappearance of our reserve grain supply and new legislation on Food Aid in 1966, our national policy has changed from one of surplus disposal to a planned program of production for home needs, for commercial exports, and for Public Law 480 use. Estimates are that one-half of our reserve cropland will be back in production this year. The ability of the United States to supply the food needs of the developing countries is rapidly diminishing in the face of their exploding populations. Dr. Paul Mandelsdorf of Harvard University calls attention to the fact that we are now exploiting the products of basic research done almost a half century ago, and to a considerable extent the sharp advances in yield per acre from improved varieties and heavy use of fertilizer are not likely to be repeatable. The U.S. Department of Agriculture has estimated that land clearing, drainage, and irrigation could bring an additional 150 million acres of U.S. land into production but the cost might be as high as $50 billion. It seems obvious that this is not the solution to world food needs. Man must eventually learn to control population, and there is some promise that progress is being made. In the short run, he must learn to increase the supply of food to match or exceed the current increase in the number of people.

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Food From the Ocean and Other Sources

It is often suggested that we must "turn to the ocean for food." Oceans and inland fresh waters have vast potential for increasing man's food supply. However, at the present time they provide only 1 percent of the world's total food. Unless there are radical changes in methods of harvesting, it is generally agreed that the present fish harvest can be increased only by a factor of two. It is true that world fish harvest has increased five-fold since 1930, but people are eating very little more fish. Much of the increased harvest is fed as fish meal to poultry, swine, and cattle for conversion to animal protein in the protein rich countries of North America, Europe, and Japan. It is not utilized in the developing countries where the need for high quality protein is urgent. The fault of this maldistribution lies in lack of purchasing

power in the developing countries which in 1963 bought only 14 percent of world imports of fish, even though they hold two-thirds of the world's people.

Yeast, algae, and other microorganisms have been shown to be more efficient than livestock in producing protein, but commercial utilization is not yet possible. The so-called "meat analogues" made from spun protein isolated from soybeans, with food value approaching that of milk and meat products, are now being market tested at prices somewhat lower than meat. These are likely to find a place in our own markets, but manufacturing and distribution costs plus lack of purchasing power will prevent their use in the developing countries for some little time. Most of the amino acids can be synthesized biochemically and could be used to fortify vegetable protein with the essential amino acids in which they are deficient. Some of this is being done, but the major problem for the developing countries again is one of cost and distribution. The surplus wheat we are shipping to India could be fortified by the addition of synthetic lysine except that it is now too expensive to do so.

The thinly populated tropics, Brazil and the Congo, are often cited as examples of large land masses that could support hundreds of millions more people. Actually these areas hold very little short-run promise for relieving world population pressures. Capital for development of agriculture and heavy industry is scarce; the technical knowledge to use in development of their agriculture is scanty; and the social and political consequences of moving millions of people halfway around the world are tremendous. Furthermore, transportation and resettlement costs to move 14 million persons from India to Brazil each year could easily run to $5,000 per person or $70 billion.

Desalinization of ocean water, if done cheaply enough, could make the deserts bloom in Australia, the Sahara, and other places. Suffice it to say that the cost of desalinized water for agricultural use is prohibitive in the foreseeable future.

All of the above ideas are potentially valuable and merit further investigation, but in the next decade or two it is extremely unrealistic to expect that any of these will reduce the rising demands on conventional agriculture.

Agriculture in Developing Countries

Since the problems of improving food production in India are typical of those of many other developing countries, and because the University of Missouri has a program in India, I shall confine my remaining discussion to the problems of improving agriculture in that country.

The runaway population of India passed 500 million last summer. Unless modern birth control methods are adopted soon, the population is almost certain to exceed one billion by the year 2000. Food grain production has slowed during the past six years after making favorable gains through land clearing and irrigation schemes.

India's food production must be tripled by the end of the century to take better care of a doubled population, and it must be done with the present cropland. This does not seem impossible because crop yields per acre are generally about one-fourth those of the developed countries. Lack of fertilizer limits yields more than any other factor. The Indian government has been slow in meeting this need because of the capital required and a fear that the cultivator would not use the fertilizer. The four pounds per acre of plant nutrients now in use compares with 150 to 200 pounds in many of the developed countries. About $100 million are required to build a fertilizer plant producing 1000 tons of plant nutrients per day. Based upon one ton of plant nutrients producing ten tons of cereals, 36 million calories, the annual output of such a plant would provide 2400 calories daily for 15 million people. Many such plants must be built in the next decade if India's food production is to gain on its escalating population. Their cost is only part of the total cost of providing fertilizer at the farm level. Raw materials, transportation, storage, distribution, and marketing costs plus research and education in the use of fertilizer must all be considered.

The other major factor in achieving increased production per acre is improved varieties. Rice is the most important food crop in India. Considerable data show that Taichung Native No. 1 rice, recently introduced from Taiwan, will yield almost double that of the local rice varieties when both are under heavy fertilization. IR-8, a new strain recently released from the Philippines has even higher yield potential. The

new, short-strawed, high-yielding Mexican wheats have performed well in India thus far, though they are susceptible to certain diseases and lack grain quality. High-yielding varieties are the best possible stimulus to increased use of fertilizer by the Indian farmer, but it is extremely hazardous to put new varieties into farm production without adequate testing, as has been done in India during the last two years. When Taichung Native 1 was grown in Orissa State last year it was injured by bacterial blight especially on poorly drained soils. IR-8 is susceptible to the blast fungus and to bacterial leaf blight and has shortcomings in grain quality. Dr. Lester R. Brown, Administrator of U.S.D.A.'s International Agricultural Development Service, has this to say about the need for research. "The Rockefeller Foundation working in the Philippines is making impressive progress in developing new, more productive varieties of rice. The next, and perhaps most difficult step, is to adapt these varieties to local growing conditions throughout the rice belt of Asia. More research, especially adaptive research, within and by the less developed countries is a key factor in solving the world food problem. Until now most of the more spectacular research successes in the less developed countries, particularly in plant improvement, are attributable to the private U.S. foundations; but they cannot do the entire job. Our AID programs must include the building up and staffing of effective research centers in the less developed countries, along with training programs to increase the number of effective agricultural scientists."

In the last ten years hybrids of sorghums, millets, and corn, all used as human food in India, have been developed through joint efforts between Indian scientists and those with the Rockefeller Foundation in India. These hybrids yield 50 to 100 percent more than the local varieties. Systems for production and distribution of these seeds are just now being developed, and in addition, farmers must be taught to buy new seed each year otherwise they lose the value of the hybrid.

The Indian subcontinent is fed with summer monsoon rains from June to September, followed by winter seasons so dry that winter crops are poor in spite of the mildness of the climate. Because of the vagaries of the monsoon rains and the need for double cropping, over 70 million acres are now irrigated in India, and there is potential for irrigation of about 175 million or about half the total arable land, but capital requirements are very large.

Pesticides for control of insects, weeds, and plant diseases are needed in increasing amounts in India. Japanese farmers in their highly developed agriculture spend as much for agricultural chemicals as they do for farm machinery. Fortunately, the capital costs for pesticides are not so great as for fertilizers. With suitable research and education their use should increase at a satisfactory rate.

The rate at which India increases its agricultural production in the years ahead will depend greatly upon the speed with which it builds fertilizer production capacity, develops and distributes vastly improved crop varieties, increases the amount of irrigated land and provides proper price incentives to the cultivators.

Quality of Food is Important

If one looks at India as a biological problem, the livestock population is in direct competetion for food with the human population. Cattle, water buffalo, sheep, and goats total over 300 million of which about two-thirds are cattle and buffalo. The burden of excess cattle on the scarce food supply in India is widely deplored in the United States. Perhaps it should be more widely appreciated here that the bullock supplies most of the farm power and provides 70 percent of all the transportation in India while existing mainly on roughage and overgrazed pastures. In the United States over 1600 pounds of grain are used per person per year, about 90 percent of this is consumed in the form of meat, milk, and eggs. In India less than 400 pounds of grain per person are available, but only 10 to 15 percent is used for animal feed. It is true that religious veneration of the cow prevents proper management and disposal of overage animals, and it is certainly true that Indian agriculture could profit by providing a better fit between cattle numbers and feed supply. Religious attitudes change slowly but they do change in time. It is easy for us to become too preoccupied with this problem in India and fail to focus on the real need for helping India to improve its food production so that both people and livestock have more

to eat. There are no religious barriers against improving yields of rice, wheat, and other food grains.

Numerous studies show that half or more of the Indian population is undernourished as indicated by an intake some 300 calories less than minimum dietary standards. Child mortality rates are estimated to be five to ten times higher than ours and are from a synergism of protein malnutrition and infection. Attempts at solving this malnutrition have placed stress on increasing the amount of animal protein in the daily diet. It is much easier to say that the scarce animal protein foods should be reserved for those who need them most than to accomplish this feat in a country having little of the modern food processing, storage and distribution systems we take for granted here. Lack of purchasing power, lack of education on the nutritional benefits of certain foods, and prejudice against most animal sources of protein also make it difficult to improve nutritional levels. In the average Indian diet, cereals such as rice, wheat, millets, and corn plus various seed legumes called pulses, provide 75 percent of the calorie supply and 85 percent of the protein supply. The daily protein intake, estimated to be far below minimum standards of FAO, consists of 31 grams from cereals, 13 grams from pulses, 5 grams from milk and the remainder, totaling 1.2 grams, from fish, eggs and meat. The average US diet contains 66 grams of animal protein compared to 6 for India. Indian scientists and administrators talk bravely about breeding better milk animals and improving disease control and feed production for cattle in order to increase the availability of animal proteins. Nutritionists are taking a more realistic attitude and turning increasingly to low-cost vegetable proteins to solve the problem. Plans are underway for production and distribution of "bal a har" which means literally "nutritious child food." Indian cottonseed meal and peanut flour, both formerly used as fertilizer, are combined with U.S. grain supplied under Public Law 480. Vegetable protein mixtures of this type have been shown to relieve symptoms of protein malnutrition in children and can be produced at one-fifth the cost of milk. It remains to be seen how this food is accepted by the Indian consumer, and whether the program can be successfully put on a commercial basis.

One is impressed by the magnitude of the job of distributing such a nutritious food even though low in cost; there are about 65 million children under the age of five to be reached. Over 80 percent of the Indian people live in villages, most of which are under 2000 in population. In the smaller villages there are no ordinary stores as we know them. The people living there must walk or go by bullock cart several miles to a market village. With an annual income of about $70 the average villager can do little more than purchase the bare necessities of life.

It would seem that in the long run the solution to the nutritional problems of India must come from increased production of a variety of cereals, pulses, fruits, and vegetables around each village so that home prepared foods can provide adequate nutrition. Then there would be no need to purchase specially prepared foods in order to have a healthful diet. The beans, peas, and other pulses commonly grown in India contain 20 to 25 percent protein and when combined with cereals having only 7 to 11 percent protein, the mixture is short of the protein concentration necessary for children. Soybeans, which are not used to any extent in India, contain about 40 percent protein and could provide the needed protein concentration. It is indeed remarkable that the soybean has not been accepted in India in view of its long history of use in the neighboring oriental countries. It should be no great problem to select varieties of soybeans adapted to every part of India, but changing food habits may be almost as difficult as changing religious beliefs. Whether a serious attempt to introduce the soybean to Indian agriculture would be successful is a real question, but there is no doubt it could make an important dietary contribution until the time when India can develop adequate supplies of animal protein.

The possibilities are bright for genetic manipulation of the cereals to increase both level and quality of protein. The Opaque 2 and Floury 2 genes of corn can be used to improve corn protein to a quality level approaching that of milk. It is reasonable to expect that similar genes may be found in wheat, sorghum, and millets, the major food grains of India, and several scientists around the world are working toward this possibility. Fortunately, rice has a protein rather well-balanced for essential amino acids, but an increase in rice protein level could play an important part in improving nutrition.

Closer cooperation between biochemists and

plant breeders now becomes a necessity. The National Academy of Sciences reported recently that "the long desired goal of the design of crop plants to exact specification is now coming into view." For India, this could mean lodging resistant, nitrogen responsive, disease resistant cereal varieties with higher levels of protein balanced in essential amino acid composition. If priority were given to this research, India might be freed from the necessity of doubling its animal protein supply in order to have healthy children. Development of plants with more and better protein seems the most feasible way to short circuit the expensive process of converting plant protein to animal protein for human needs. Plant protein produced per acre of land is three to ten times that which can be obtained from milk and meat.

Summary

The ability of the United States to meet the expanding food deficits of the developing countries is rapidly diminishing. Population control in the less developed countries is the ultimate goal, but until reached, their food production must be increased at an accelerated pace. In the foreseeable future, conventional agriculture must bear this burden.

For India, the answer lies in increased yield per acre by use of more fertilizer, better varieties, more pesticides, and more irrigation in an agriculture provided with adequate price incentives and credit. Agricultural research of all kinds must be increased with priority given to adaptive research in crop production featuring plant breeding, crop protection, soil and water management, irrigation, and farm management economics. Extension education must be increased and made more effective, particularly in crop production and human nutrition.

The answer to food production in a few other developing countries may differ substantially from India. Extensive land is available in some for a sound animal agriculture. Lack of political stability or land reform sometimes inhibits agricultural development even when the necessary technology is available. In these countries, the methods and priorities will differ.

Public opinion, government policies, and the historical development of the land-grant universities increasingly commit our agricultural colleges to an expanded role in assisting developing countries to solve their food production problems. Our scientists and educators must join hands with their counterparts abroad in this most urgent task. Since our current research and education programs seem to demand all of our available manpower at home, ways must be found to release some of our scientists for foreign service and to attract and train new manpower in the special skills needed for international agricultural development. Eradicating hunger in this century is a difficult problem, but need not be an impossible one.

Discussion Summary:

Implications of World Situation for Missouri Agriculture

JERRY G. WEST, MODERATOR*

1. **How will the world food situation affect the demand for and prices of Missouri farm products?** Missouri farmers will benefit from increased export demand as will other producers in other states. Those farmers producing commodities which are exported in large quantities will be affected more than others. For example, those farmers selling wheat, soybeans, and to a lesser extent feed grains will see the export market becoming even more important as a factor affecting farm prices. On the other hand, livestock producers will not be affected much since livestock products are not exported in large quantities.

2. **What will be the effect of the world food situation on government farm programs?** To some extent the answer to this question is already obvious in the recent changes in efforts to reduce production. The incentives to take land out of wheat and feed grain production have been altered to encourage an increase in production compared to the level in recent years.

   Surplus stocks no longer exist for wheat and wheat grains. In fact, there is concern that the carry-over is inadequate for emergency reserve purposes. Changes in programs for 1967 were designed to provide for some increase in reserve supplies.

3. **Are there any implications for agri-business in Missouri?** Dr. Gillis indicated there were at least two to be considered. First, firms would probably experience some increase in the demand for their services as production expands. This would be true for firms in the farm supply business as well as those marketing the output of Missouri farms. Again, those firms serving producers of those commodities moving into the export market will be affected most.

   Secondly, many of the firms operating in Missouri will have a role to play in helping to expand production overseas. If production is to be increased in the underdeveloped countries their farm input industries and marketing systems will need to make substantial changes. Our agri-business firms with their capital and know-how can make real contributions if the political climate in these countries will permit.

4. **Will the University of Missouri and other agencies concerned with research and educational activities be affected?** Dr. Pinnell suggested that the attitudes and enthusiasm of people working in these areas were already changing. The transition from a surplus-dominated philosophy to one of need for greater production both at home and abroad is having an impact.

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There is general agreement that the need for adoptive type research in the developing nations is great and that professional workers in Missouri and other states will need to contribute toward this effort.

Summary. World food needs are expanding and the situation will become even more serious in future years. Efforts to stem population growth, increase production of food in the developing nations, and expand food production in the U. S. to help meet emergencies overseas will all be necessary. The problem will need to be attacked on several fronts. Studies of food needs make it obvious that increased shipments of food from the United States will likely be needed but this is not the long-run solution.

The capacity of underdeveloped and developing nations to meet their own food needs must be increased. They must take simultaneous action to limit their population explosion and increase their food production. Missouri and other states will be called on to help in the solution of the problems involved.