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THE AGRICULTURAL DILEMMA

Doubtless there are all sorts of reasons why historians should take note of the 1790's, but for the purposes of this lecture, to an audience composed largely of professional agriculturists, I want to draw attention to just two out of the ten years of that decade - 1796 and 1798. In 1796 Edward Jenner inoculated an eight year old boy with fluid from the cowpox vesicles on the hands of a milkmaid, and showed by subsequent exposure to a smallpox epidemic that the boy had become immune to that serious disease. Then in 1798 a country curate, Thomas Robert Malthus, published a slim volume entitled "An Essay on the Principle of Population as it affects the future Improvement of Society". These two events, the one involving an experiment by a physician on his patient, and the other an intellectual enquiry into the dynamics of human population are, in their separate, but as I hope to show converging ways, of significance to the current world situation.

Before developing this theme, it is necessary to set the 1790 decade in some sort of historical and demographic perspective. Between 1200 and 1500 A.D. the people of England suffered a major famine on the average of once every fifteen years; and those who survived the famines still had to contend with wars, plagues and pestilences. Thus in one year alone it is estimated that a quarter of the English people died in the Black Death. And despite the lack of accurate and consistent records, there is reasonable evidence that between 1200 and 1500 the population of England, along with that of the rest of Europe, slowly but steadily declined.

Historians place the beginning of the modern era at some time around the year 1600 when the downward trend first gave unmistakable signs of being reversed. They estimate that by 1650 the population of Europe, which had fallen to as low as 60 million, had recovered to 100 millions out of a world total of perhaps 450 millions. The reasons for the reversal are obscure. Living conditions were, by present day standards, inordinately bad, but changes, deepseated and far reaching changes, were taking place. James Watt's invention of the steam engine and Arkwright's spinning frame were ushering in the Industrial Revolution; in the century and a half between 1650 and 1800, no major epidemic decimated the population; and the European dietary was progressively improved through the introduction from America of new crop plants, notably potatoes, and through the importation of staple

foodstuffs. But the fact remains that despite progress in terms of industrialisation and an improved food supply, the numbers of the poverty stricken had not decreased. Indeed the reverse seemed to be true.

During this same period there was also a much less tangible change, but one which in its ultimate effects were equally deepseated and far-reaching. The poverty and degradation which characterised the great majority of people, allied to the primitive methods of communication between individuals within a community and between communities, could not entirely prevent the spread of ideas. And among these ideas by far the most important was one of opposition to authority and of assertion of individual liberty. Even in their embryonic form these ideas led to rejection of the age-old pious belief that conditions of utter misery represent the inevitable will of God; and the opinion grew rapidly that everybody should participate in the rights granted by Magna Carta more than 500 years before.

This new doctrine, developed in France by Rousseau, and in America by Franklin, Paine and Jefferson, culminating in the American War of Independence and the French revolution, did not lead to similar violent upheavals in England. But it had its effect in the writings of men such as Bentham, Godwin and Owen who, during the late 18th and early 19th centuries, demanded that something be done to relieve the growing number of Englishmen condemned to direst poverty. Their publications are of importance because they reflect not only the inarticulate aspirations of the depressed majority, but the growing social concern among the more fortunate minority.

It is on to this inadequately furnished stage that I want to introduce Jenner, the physician, and Malthus, the social analyst and demographer. Malthus wrote his first pamphlet because of his vehement opposition to the social reformers like Godwin and Owen who, through their idealistic programmes, were proposing to treat symptoms and not causes. Thus in relation to Owen's plan for curing English poverty by establishing small industrial co-operatives Malthus writes thus ".....but in the plan which he has proposed he seems totally to have overlooked the nature of the problem to be solved. This problem is, How to provide for those who are in want in such a manner as to prevent a continual increase in their numbers and of the proportion they bear to the whole society. And it must be allowed that Mr. Owen's plan not only does not make the slightest approach towards accomplishing this object, but seems to be peculiarly calculated to effect an object exactly the reverse of it; that is to increase and multiply the number of paupers."

Malthus based his criticism on two basic propositions. The first is that the reproductive urge in human beings is so strong that there is an inexorable tendency for numbers of people to exceed the means of subsistence; and he pointed to the demonstrated capacity of the human race, given favourable conditions, to double itself every 25 years, i.e. to increase in geometrical progression. On the other hand, although he had no agricultural statistics to prove his contention, he could not envisage food production increasing in better than arithmetical progression.

His second major proposition stems naturally from this last assumption about potential increases in food supply. Malthus recognised that the inherent tendency of populations to increase in geometrical progression is defeated by certain positive and preventive checks. As positive checks he lists in particular three manifestations of what he defines as misery and vice - war, famine and pestilence. His preventive checks, and he wasn't very optimistic about them, were moral restraint, late marriage and considerable continence after marriage.

The proposition that populations inevitably grow more rapidly than any increase in the level of subsistence had been stated long before Malthus published his essay. Le Gros Clark in the book "Four thousand million mouths" quotes Holinshed as saying in 1577 "Some men were affirming that we had too great a store of people in England, that youth by marrying too soon do nothing to profit the country but fill it full of beggars to the hurt and utter undoing of the Commonwealth." And another notable figure of that so-called Golden Age of Elizabeth I, Sir Walter Raleigh, expressed his opinion that the earth would not only be full but overflowing with human beings were it not for the effects of hunger, pestilence, crime and war, and of abstinence and artificial sterility. And Clark makes the point that Holinshed and Raleigh are only two in a long line of historians and philosophers who had thought and written about the rise and fall of human numbers.

The question naturally arises : Why did the publication of the Essay in 1798 create so much interest? because I think it fair comment that few doctrines have excited more controversy or aroused more bitter criticism over so long a period of time. I can't answer that question except in terms of the old adage that times produce the man. More important questions are "What were some of the effects, both tangible and intangible, both short term and long term, of the Malthusian hypothesis? How well have his postulates stood the test of time? How applicable are they to the world of 1970?

Biologists of all persuasions have been fundamentally influenced by one of the intangible effects, viz. its influence on Charles Darwin. Here is what Darwin says in his autobiography. "In October 1838, that is fifteen months after I had begun my systematic enquiry I happened to read for amusement Malthus on Population, and being well prepared to appreciate the struggle for existence which goes on everywhere....., it at once struck me that under these circumstances favourable variations would tend to be preserved and unfavourable ones to be destroyed..... . Here then I had at last got a theory by which to work." It is certain that had Darwin not read Malthus he would still have hit upon the concepts of natural selection and the "struggle for existence". From Darwin's own account however it is equally certain that crystallisation of that concept owed much to Malthus' ideas.

It comes as something of a shock then to realise that if Western Europe, over the century and a half following publication of the Essay, is used as a yardstick, the doctrine is sadly astray. So far astray indeed that in the twenty years following World War I, but by no means solely as a result of the millions of deaths it caused, there was a minor panic in a number of European countries: the birthrate was falling to such an extent that serious demographers were talking in terms of national suicide. The Swedish Government was so concerned about it that in 1934 it set up a Commission on Population, composed of leaders in the fields of vital statistics, economics, genetics and medicine, and charged with making recommendations designed to bring the birth-rate up to a point where it at least balanced the death rate. The Commission's report was lengthy and imaginative and many of its recommendations were enacted into law in 1937 in a session which has since been called the "Mother and Childrens Parliament". Indeed the legislation represented a major step along the road which has made Sweden's welfare services a model for the whole world.

Since we can't run controlled experiments on human births and deaths it is impossible to say whether or not the increase in the Swedish replacement index to above parity by 1945 was a direct result of that legislation. Frankly I doubt it, since in a number of other countries in the same predicament as Sweden, the birthrate also increased. But be that as it may it is clear that the actuality of the 1930's was a far cry from the Malthusian hypothesis of 1800.

The paradox is obvious. Here we are in 1970 talking more and more frequently and apprehensively about the population explosion: yet only forty years ago a substantial part of the western world was not even vaguely concerned about the pressure of population on the means of subsistence, at least in the Malthusian sense. On the contrary, as illustrated by the Swedish action, there was considerable pressure on people to reproduce at a rate which would ensure at least parity between births and deaths.

Where did it all go wrong? To try to answer that question I should like to take the propositions in the Malthusian hypothesis and examine them in relation to changing circumstances over the subsequent 140 years. Let us look first at the positive checks to population growth listed by Malthus - war, famine and pestilence. In a brief analysis of that period I think we can dismiss war as causing a significant decrease in human numbers. At least some of us in this Hall have lived through two world wars of quite unprecedented destructiveness. Yet despite the sudden increase in the death rate over substantial areas of the globe, they caused only a slight tremor in the curve of overall population growth. Throughout the combatant countries, including those most directly affected, there seemed to be an instinct for national survival, or perhaps I should say family survival, which resulted in higher birthrates during and particularly after the war.

I don't want to discuss famine as a positive check since famine necessarily involves food - or lack of it, - food necessarily brings in agriculture, and I should like to discuss agricultural production later. However, in considering the fate of the Malthusian hypothesis it is necessary to refer to one matter, the effect of which Malthus could not have foreseen, viz., the effect on food availability in western European countries of the revolution in transport resulting from the introduction of steam power. Famines have always been local phenomena, and throughout history could have been alleviated if food surpluses elsewhere, perhaps only a hundred or two hundred miles away, could have been transported to the famine area.

Steam transport for shipping lines and railroads transformed this premise into reality. And it happened at a time when the countries of the New World were seeking markets in Western Europe for ever increasing surpluses of grains and other foodstuffs. I think you will appreciate what a weapon this proved to be in the hands of the anti-Malthusians. Taking England as an example, her population during the 19th century grew from 16 to 27 millions, an increase of 70%. During that time homegrown food production increased only slightly if at all, yet not only had there been no famine, but at the end of the century more people were better fed than ever before. On this evidence alone, said its opponents, the Malthusian hypothesis was demonstrably false.

Now to the third of the positive checks, and here we return to the 1790's and to Dr. Edward Jenner. But just to keep the record straight we should really pay tribute to Lady Mary Montagu who accompanied her husband to Constantinople in 1716, when he was appointed Ambassador. She was amazed to find Turkish parents inoculating their children with the crusts of sores from very mild cases of smallpox; and equally amazed to find that this hazardous treatment generally resulted in only a mild infection which then conferred complete immunity in subsequent epidemics. She came back to England

full of enthusiasm, and despite intense opposition from the medical profession inoculated her own children, saw them survive, and not only survive but achieve immunity to subsequent infection. However, the forces of reaction were too strong and the matter was forgotten until fifty years later when Jenner read about Lady Mary Montagu's activities, integrated them with his own shrewed observations on the apparent immunity of milkmaids to smallpox, and performed his historic experiment.

The results were spectacular. Despite the most violent opposition from his own profession, Jenner and his disciples vaccinated twelve thousand people in 1803; and in 1805 the annual number of deaths from smallpox in London fell from over 2000 to 622. For the first time in the history of the world a weapon had been forged to control one of the most dreaded epidemic killers.

It must be realised of course that nobody had a clue as to what smallpox was, how it was transmitted or why vaccination was so dramatically successful. Of course dozens of people tried to prepare vaccines against diptheria, measles, malaria and other killing diseases, but in no case were they successful.

Explanations however, were on the way. It was in 1762 that a Hungarian biologist, intrigued by what he observed through his microscope of the "little beasties" described by Leeuwenhock, suggested that contagious diseases might be caused by invasion of the human body by these microscopic organisms which we now call bacteria, different diseases being the result of attack by different kinds of bacteria. Of course so absurd and revolutionary an idea had to lie fallow formany years, and its importance only began to be realised following Pasteur's experiments, not on the causes of human diseases, but on the nature of fermentation processes. In the first half of the 1860's Pasteur showed that the wine spoilage which was threatening the whole French wine industry, was the result of the contamination by bacteria of the wine after yeast fermentation had ended, and the wine was maturing.

Now, argued the British microscopist and surgeon, Joseph Lister, if the sickness of wine is the result of invasion by these minute organisms, is it not probable that bacteria could invade the human body with equally dire results? And what better point of entry for the invaders than the wound caused by the surgeon's scalpel? In answering these questions Lister opened up the whole field of antisepsis; and instead of surgery being regarded as the last resort and the almost invariable death warrant for the patient, it suddenly blossomed into a major instrument of cure. Shortly after the introduction of phenol and sterilization to the operating theatre, Lister was able to report that 34 out of 40 operations had been successful.

I'm not going to give a list of diseases which one by one were conquered, nor to describe the parallel advances in public health and preventive medicine. For our present purposes it is merely necessary to make the point that in the period 1800 to 1940 pestilence, the third of Malthus' positive checks had largely lost its menace. This is apparent in the dramatic fall in death rates throughout Western Europe. Again using Sweden as an example the deathrate decreased from 26 per thousand in 1800 to 11 per thousand in 1940. Or to use an equally revealing statistic, the life expectancy at birth rose from 37 years in 1800 to 67 years in 1940.

Hence of the three major factors listed by Malthus as controllers of population growth, war, famine and disease, it was clear that in Western Europe they had largely lost their effectiveness. If his theory were correct, human numbers should have vastly and progressively increased. Actually at the end of the period they were threatened with decline; and the Malthusian hypothesis, said the critics, was clearly untenable.

Let us look next at the preventive checks i.e. those which are purely voluntary and which operate by restricting births, not by causing deaths. Malthus has this to say about them: "With regard to the preventive check to population, though it must be acknowledged that that branch of it which comes under the head of moral restraint does not at present prevail much among the male part of society; yet.....it can scarcely be doubted that in modern Europe a much larger proportion of women pass a considerable part of their lives in the exercise of this virtue than in past times and among uncivilised nations."

But regardless of whether males or females could claim the credit, there is no doubt that moral restraint, which was seen by Malthus as chastity before marriage, late marriages, and considerable continence after marriage was having a definite effect in Europe by 1800.

Ireland provides an instructive example of both positive and preventive checks. In 1800 its population was 5.3 millions; forty years later it had risen to over 8 millions. Not the doubling in 25 years which Malthus had showed was possible under favourable conditions, but an unprecedented rate of growth nonetheless; and there is little doubt that the increase was a direct result of the potato, which had been introduced from America and which flourished amazingly in the Irish environment. Then disaster in the shape of potato blight struck in 1846, resulting in a 3 year failure of the crop, a failure which brought into immediate operation the positive check of famine. Nearly a million people died between 1846 and 1851 and more than a million emigrated. Then came the preventive checks which Malthus regarded as the only method of keeping the birthrate down: few marriages which means a high level of celibacy, and late marriages. And a century after the failure of the

potato crop the Irish population stood at 3 millions.

But clearly the positive check engendered by a particular crop failure and the preventive check of moral restraint are hardly adequate to explain the population trends in Western Europe up to 1940. Again the reason viz., the introduction and widespread use of contraceptives, was one which Malthus could not have foreseen; and indeed it would be very interesting to know what his reaction would have been. I suspect that he would have been in a serious dilemma. His attitude to sexual promiscuity and to incontinence both inside and outside marriage are clear and uncompromising, and it seems probable that he would have regarded contraceptives as instruments of vice. On the other hand he would have been forced to admit that they represented a much more potent preventive check on population growth than those that he had postulated in his essay.

I have spent some considerable time analysing the Malthusian hypothesis during the first 140 years of its existence. To close that part of this lecture and to demonstrate how rapid can be the change in informed opinion in matters of population dynamics I would quote the distinguished John Hopkins demographer Raymond Pearl. In 1937 he delivered in London the Heath Clark Lectures under the title the "Natural History of Population." Malthus is mentioned only once in the index of a book which runs to more than 400 pages; and in the text Pearl refers to (and I quote) "the gloomy prophecies about the future of mankind which seem comically absurd soon after Malthus made them. To this day people who because of geographical location, climatic conditions and other causes have been unable to participate in any real sense in the consequences of an expanding effective universe, are still growing in population very slowly if at all."

That conclusion was reached only a little more than one generation ago, and I might add that Pearl was by no means alone in his analysis of population trends. Hindsight inevitably leads to the question: Is it the Malthus of 1800 or the demographer of the 1930's who is comically absurd?

I don't propose to bore you with a description of the present population crisis. Through books, pamphlets, reports of symposia, by press, radio and television, the facts of population growth are too well known to bear repetition. But it is of interest to apply the Malthusian postulates to our current and future populations, and to look at some reasons for the diametrically opposed population trends of Western Europe from 1800 to 1940, and of the world from 1940 to 1970 and then on to 2000.

Firstly you will recall that Malthus produced evidence showing that the human race, given favourable conditions, could double itself every 25 years; i.e. it could increase in geometrical progression on a 25 year time base. He drew his evidence from relatively small isolated communities, whereas we are now witnessing a comparable rate of increase on a global scale. With more than half the world's population on the verge or over the verge of starvation, nobody can describe present world conditions as favourable. Yet demographers calculate that by the end of the century the 3000 million figure of 1960 will have grown to at least 6300 millions by 2000; and a more realistic estimate is nearly 7000 millions. Hence we are witnessing a doubling of the world population, if not in 25 years, at least in less than 40 years.

Your immediate reaction to those estimates might well be one of scepticism. After all, only forty years ago Raymond Pearl and his colleagues had calculated from the data then available that human numbers would increase only slowly. If they could be so fantastically wrong in their forecasts, is there any guarantee that present day demographers are any more accurate about the next 30 years. Of course there can be no unequivocal answer - only time will tell. My own belief is that the assumptions underlying the forecasts are soundly based, and that the forecasts themselves are conservative. In particular there is the unassailable fact that the number of females who will be of child bearing age during the period 1970 to 2000 is already known quite accurately. Unless there is a remarkable change in patterns of sexual behaviour the increases I have mentioned seem inescapable.

Earlier I pointed out that the two most destructive wars in history had not caused any substantial change in world population trends. And this of course is also true of the wars which have been waged continuously since the end of World War II, twenty five years ago. But it would be a rash person who predicted the effect of war in the next 30 years. No less than five nations have developed weapons based on nuclear fission or nuclear fusion, and it is no secret that the two super-powers have stockpiled sufficient to put an end to the human existence on this planet. Doubtless they will be joined by others before the end of the century, and the only reason that anybody should be worrying about populations pressures in the year 2000 is fear: fear of certain and instant reprisal. I am sure that Malthus would have regarded nuclear warfare as the ultimate positive check.

If we turn now to pestilence, Malthus' second positive check, the knowledge which had accrued in disease prevention and cure up to 1940 has vastly increased in the past 30 years. Two examples of our wider knowledge, penicillin and DDT, have become such familiar terms all over the world that it is hard to believe that they were only scientific curiosities in 1940.

The fight against diseases caused by bacteria was greatly aided by the discovery of the bacteriostatic action of sulphanilamide, and its analogues and derivatives, in the 1930's. But it was only with the development of methods for mass production of penicillin, and the subsequent discovery and production of a whole host of other antibiotics, that the conquest of practically all diseases of bacterial and fungal origin has become possible. A statistic which I should love to have, but which is impossible to obtain, is the number of deaths which have been prevented (or perhaps postponed would be a better word) as the result of antibiotic therapy.

Although DDT is not a cure for any disease and although it operates indirectly through killing the insects which carry disease, its effect on death rates has been at least as spectacular as has that of the antibiotics. There must be many in this audience who remember the dramatic control of an outbreak of typhus in Naples immediately after the war. This louse - transmitted virus disease would undoubtedly have reached epidemic proportions but for the liberal use of DDT on every person in the city whom the U.S. Medical Corps could round up. The vectors were killed and with them the epidemic.

In terms however of its effect on population growth one example must suffice. In his book "Human Fertility" Robert Cook cites the case of British Guiana at about the same time as the Naples incident. Infant mortality was at the frightfully high figure of about 300 deaths per 1000 births, the cause being attributed largely to insect-borne diseases. A 10 mile square area, including the city of Georgetown, was sprayed periodically with DDT between 1946 and 1948. The effect was immediate and spectacular - infant mortality rates dropped by about 80% to 67 per thousand births; and the birthrate itself rose appreciably. This abrupt change in birth and death patterns is reflected in population data: in 1955 the crude birthrate was 43 per thousand and the crude death rate 18 per thousand. It doesn't require a mathematical genius to determine how these figures fit in with the postulate of geometrical progression.

Now - let us turn to food and to the agricultural industry which produces it. You will recall Malthus' argument that whereas the human race was capable of doubling itself every 25 years, he could not envisage food production increasing in better than arithmetical progression. Hence his postulate that in any community or in any country, there is an inexorable tendency for numbers of people to exceed the means of subsistence.

You will also recall that if Western Europe is used as an example, his postulate was clearly untenable. During the hundred years following publication of his Essay, human numbers in Western Europe increased at a rate far greater than had occurred in any previous century. Yet although homegrown food supplies had increased only marginally, far more people were fed better than ever before. As an introduction to what I have called the agricultural dilemma it is necessary to repeat the reasons: the opening up of vast new areas in the Americas, Australia, South Africa and New Zealand, resulting in a production of food greater than could be consumed within the producing countries; the use of steam power to transport the surplus and distribute it in Western Europe; and massive emigration from the old world to the new.

So, the nineteenth century was characterised by a huge increase in food supply consequent upon the expansion in the area of arable land. But the last decades of the century were notable for another change - scientific agriculture was born and flourished, with consequences even more far reaching than the exploitation of the lands of the new world. Although the area of arable land has continued to grow during this 20th century, the rate of growth has progressively declined, since the world's potentially productive land is after all finite in area. Science applied to agriculture has resulted in the capacity to produce, on each acre of land, more and better plants, and more and better animals. And the decline in the growth rate of area of arable land has been more than offset by the efficiency with which it can be managed in order to produce food and fibre.

Accurate vital statistics in simple terms of births, deaths and total numbers are notoriously difficult to collect in underdeveloped countries, and there must be a significant margin of error when ever world population figures are quoted. There is at least as great a margin of error in estimating food production and since these errors may be cumulative in some cases and self cancelling in others, it is difficult indeed to work out the Malthusian equation relating world population to global means of subsistence.

But despite these uncertainties the following statements appear to be beyond dispute:

1. Present world numbers are about 3500 million
2. For some years the world population has been growing at about 50 million per year. The rate of increase is highest in Asia, Africa, Central America and South America.
3. Since World War II agricultural production has been increasing at a somewhat higher rate than human numbers, but a substantial part of the increase has taken place in developed countries. Indeed as Australia knows only too well the increases have led to embarrassing surpluses.

4. More than half the world's population is underfed, and at least a third is permanently on the verge of starvation. Although affluent Australia has nothing to be proud of in the proportion of her people who are underfed, the situation is worst in the under-developed countries where the rate of population increase is greatest.

In his 1967 Farrer Oration entitled "Man, People and Land", Professor Underwood accepted these premises and went on to a searching analysis of the problems which must be solved if food supply is to meet present and future world demands. And in the course of that analysis he outlined a situation very reminiscent of Western Europe during the nineteenth century. A group of underdeveloped countries imported 4 million tons of grain annually between 1948 and 1952. By 1959 the figure was close to 15 million tons and by 1966 it had risen to 25 million tons. At the same time output of food per capita in non-Communist Asia dropped by 4%, and in Latin America by 5% in the 5 years prior to 1967.

The parallels with nineteenth century Western Europe are obvious: A rapidly increasing population, a more or less stable food production, and large imports of food from countries with a surplus. But the parallel stops there.

Emigration on a significant scale is impossible for our problem countries, while contraception is practised by only a tiny segment of the population. Moreover there is only the most embryonic counterpart to the Industrial Revolution which last century flourished in Western Europe and which provided employment at a rate commensurate with population growth. Underwood makes the point that the rapidly increasing numbers of people in developing countries must continue, for a long time to come, to live and find employment where they were born - on the land. And I would remind you of the frequently demonstrated correlation between growing industrialisation and a falling birthrate.

I have already indicated the poor opinion held of the Malthusian doctrine by the demographers of the 1930's, and the reasons why its postulates failed in Western Europe during the 140 years after they were enunciated. Its critics were sufficiently persuasive to convince the people of western countries that they should disregard what was happening to the other three quarters of the world's population. For the latter I believe that the basic Malthusian hypothesis was proved to the hilt and that the checks imposed by war, famine and pestilence kept populations in balance with the means of subsistence. Further I believe that Malthus is highly significant for the problems we face in 1970. Admittedly the premises on which he based his theory are no longer tenable, since modern science and technology have revolutionised our ideas on

death control, birth control and food production and distribution. Yet despite this I am convinced of the relevance of his basic analysis.

Medical science and practice, combined with measures for improved sanitation and public health, have been responsible for the dramatic fall in death rates not just in Europe but throughout the world. And there can I think be no argument that it is this fall in death rate which is the major factor in the population explosion.

I am not at all proud of it in retrospect but I must admit that I have been guilty in the past of accusing the medical profession of irresponsibility in reducing death rates without consideration of the consequences. The argument went like this. Following the war the professional agriculturists of the western world were as concerned as were their medical colleagues in alleviating distress in underdeveloped countries. Our concern was of course to ensure an adequate food supply.

We knew that by the use of modern methods, agricultural productivity in those countries could be vastly increased but we also knew the technical, economic and sociological difficulties involved in achieving this increase. If only, we said, if only human numbers could be held steady until we had overcome the backlog of hunger, we would have a reasonable chance of coping with subsequent increases. And our muttering of irresponsibility against our medical colleagues arose, I suspect, out of the envy we felt at the incredible ease and speed with which they could achieve their spectacular results by contrast with the difficulties and delays which we faced.

Reverting to the example of British Guiana which I cited a moment ago, the spraying with DDT which reduced infant mortality by nearly 80% involved no effort whatever on the part of the native population, while the total cost was only a few cents per head. Somewhat more difficult, costly and time consuming are inoculations against smallpox, poliomyelitis, whooping cough and the rest, but they are still simple procedures which can be applied on a mass basis, and which produce results very quickly.

In view of the obstacles in the agricultural path is it any wonder that we looked askance at the effects of applying medical science to underdeveloped countries? Is it any wonder that we asked the question "What is the sense in bringing about a spectacular decrease in infant mortality if the babies so saved are doomed to die of starvation later?"

I doubt if any of us really wanted to see these criticisms taken to their logical conclusion. The preservation of life, and the relief of pain and suffering, are deepseated instincts in us all, and the most frustrated agriculturist would not have denied medical care to the least developed of countries. But the facts have to be faced. The population explosion which threatens to overwhelm us, and the discrepancy which exists between the numbers of people and the available means of subsistence, are due in large measure to medical science and its application. And the only consolation for the agriculturists lay in fantasy: a vision of themselves as the modern version of the knights of old pursuing but never quite catching the dragon of starvation which had been so effectively nurtured by their medical colleagues.

That was all very well twenty years ago but our ideas have changed a lot since then; and if we're to be entirely honest we must take an equally hard look at the part played by agricultural science and its practitioners in the 1970 Malthusian equation. Are Our efforts to provide food for all the people of the world more or less praiseworthy than medical efforts to fight disease. What is the essential difference between saving a child's life by vaccination against smallpox and saving it by providing enough food to prevent death by starvation. If there is an overall and continuing shortage of food, the child may in each case survive, merely to succumb at some later date. Moreover if the child is female and if she survives to puberty, there is the added risk that human numbers will be still further increased.

I cannot help reverting to a passage from Malthus' which I read much earlier. In discussing the proposals of Robert Owen he wrote, and I re-quote "This problem is, How to provide for those who are in want in such a manner as to prevent a continual increase in their numbers and of the proportion they bear to the whole society. And it must be allowed that Mr. Owen's plan does not make the slightest approach towards accomplishing this object, but seems to be peculiarly calculated to effect an object exactly the reverse of it; that is to increase and multiply the number of paupers."

"To increase and multiply the number of paupers." I wonder what Malthus would have said had he been writing his Essay over the past 20 years. With two of his positive checks, war and pestilence virtually inoperative, how would he have described the efforts of developed countries to increase the supply of food to underdeveloped countries. I don't propose to try to answer that question at this juncture, but of one thing I feel reasonably confident. Whatever moral scruples Malthus might have had about the preventive check of contraception I am sure that he would have been in the forefront of those urging its widespread adoption.

The export of food, some paid for and some donated, is far from being the only way in which developed countries are trying to overtake and contain the hunger backlog of two thirds of the world's population. Since the end of World War II, intensive efforts have been made to increase indigenous supplies of food, efforts in which a number of people in this audience have been directly involved. And over the past 5 years these efforts have been remarkably successful, so successful that still another of Malthus' premises is in serious danger.

You will recall that in his basic proposition he stated that he could not envisage food production increasing in better than arithmetical progression. Yet we are now in process of witnessing much better than arithmetical progression in a number of underdeveloped countries. Underwood quotes the case of Mexico where in the 20 years from 1945 to 1964 the yield of wheat per acre increased more than threefold, and the national production increased sevenfold. Threefold and sevenfold in only 20 years. Not even the most enthusiastic human practitioners of reproduction could approach these increases. Indeed the results achieved in Mexico rival, in speed and in scope, those of the medical profession about which I complained a moment ago.

Dr. Keith Finlay, a former colleague of mine at the Waite Institute, and now Research Director at the International Maize and Wheat Improvement Centre near Mexico City, was in Australia a few weeks ago. He gave a first hand account of the way in which the revolutionary results achieved in Mexico are rapidly spreading through country after country where wheat growing methods have changed little over the last thousand years. A similar story can be told of rice production, and the outlook for the future can be summed up by reference to an address by Mr. O.V. Wells, deputy director general of F.A.O. Speaking in Canberra three or four weeks ago he is reported as predicting that increases in food production in the whole Asian region will overtake the rate of population increase, thus holding out the prospect of self sufficiency in cereals by the second half of this decade. A different picture indeed from the depressingly pessimistic forecasts of only 10 years ago.

And if it is a true picture, if the food explosion is about to neutralise the population explosion, another prop is being pulled from under the Malthusian hypothesis. The third positive check of starvation appears to be joining pestilence and (we hope) war in becoming inoperative.

The immediate question which comes to mind is: if our optimism is justified, if we do succeed in closing the hunger gap, what problems will we have solved? If the Green Revolution continues to gather momentum, if we find we can provide enough food for the 4300 millions of 1980 or the 6500 millions of the year 2000, what then? The dilemma is put very concisely by

another of my distinguished predecessors, Sir Otto Frankel. In the Farrer oration of 1962 he said "If a supreme effort is needed to provide for the now inevitable 6000 millions could we cope with more.....Were we to succeed in riding the oncoming wave, shall we not be relied upon to ride the next. And if so what would be the consequences for the productivity, the resources, the very structure of the earth; what the social consequences for our species, our way of life, our liberties, our civilisation?"

That was said eight years ago when few of us looked beyond the apparently unattainable goals first of providing sufficient food and then food of good nutritional quality. If we had looked beyond, I suspect we might have imagined a Utopia in which the great majority of the world's inhabitants enjoyed, in addition, a standard of living approaching that of the present minority of the affluent western world. But during the last eight years people have become aware of the damage which that same affluent Western World is doing to the environment - to our air, to our soils, to our rivers, to our lakes and to our oceans.

At this stage of the evening I am not going to inflict on you yet another dissertation on environmental pollution, but there are one or two aspects which in the context of this talk cannot be ignored. The spectacular increases in cereal production which we are now witnessing would be impossible but for adequate fertiliser application; and adequate fertilisers at reasonable prices would not have been available but for the advances made in chemical technology since the end of the war. I believe that in developing countries these new tools are being used efficiently, but if we are gazing into the crystal ball it is perhaps salutary to consider fertiliser use in developed countries as an indication of what may happen in due course on a global scale. Crop yields in the United States and Western Europe have been greatly increased during the past 20 years through heavy fertiliser application, and the cost of the extra fertiliser has been handsomely recouped in the increase in harvested product. Indeed the cost of fertiliser in proportion to the total cost of producing the crop has decreased to such an extent that wasteful application is in many places the rule rather than the exception; and applications of nitrogen at the rate of 400 lb. per acre are becoming increasingly common. Inevitably some of these applications finds its way into ground waters and hence into streams and reservoirs. And this leads to as ugly a situation as the word which has been coined to describe it - eutrophication. Perhaps by the time the underdeveloped countries get to the stage of wasteful application we may have solved the problems posed by eutrophication. And then again we may not!

When he was in Australia Dr. Finlay pointed out that self sufficiency in cereals means that in certain places and at certain times there must occur a surplus above human requirements. And the pace of the Green Revolution is such that these surpluses will grow. From the pattern already developing it is clear that they will be used for feeding domestic animals - poultry, pigs and cattle. At first glance a highly desirable development, since a cereal diet will thereby be supplemented by first class animal protein. Although there is an enormous gap between an Indian peasant feeding a cow or a few hens and pigs, and the intensive cattle, poultry and pig-production units of western countries, it is nevertheless relevant to consider what the latter entails. At a recent A.I.A.S. lecture in Adelaide, Mr. J.S. Potter graphically described intensive animal production as the "saga of the muck heap". He instanced the case of a county in Ontario situated close to Toronto and admirably suited to broiler and pig production. So enthusiastically have producers embraced intensive methods that the annual production of manure is equivalent to 2 tons over every acre of the county. Not only is there serious pollution of surface and ground waters, but the stench has caused half the population of a downwind town to move elsewhere.

Then there was the case of another company which, on a total area of 50 acres produces 800,000 turkeys and 7000 tons of manure annually.

In the environmental problems which face the world, agriculture is far from being the greatest culprit. Nevertheless there can be no doubt that it plays a not insignificant role in causing the River Rhine to be called "The Sewer of Europe," and in other similar calamities in the western world.

The question was posed earlier: if our optimism is justified, if we succeed in closing the hunger gap, what problems will we have solved. I think my answer would be obvious. We shall have solved an immediate problem only to see it replaced by others; and the greatest problem is that stated by Frankel: were we to succeed in riding the oncoming wave of empty stomachs, how can we cope the next? To me the inescapable conclusion is one that is extraordinarily difficult to accept in this least populated of the continents: there are already too many people in the world. If this conclusion is even approximately accurate, then our greatest dilemma is that an already overlarge population will almost double itself by the end of the century.

Now in conclusion may I return to Malthus and to the relevance of his eighteenth century analysis to the twentieth century situation. Malthus was as deeply concerned about poverty in England in his day as are all thinking people now about poverty throughout the world. But he did not allow his charitable instincts to cloud his reasoning processes. He

devotes a substantial part of the Seventh Edition of his Essay to a critical consideration of the Poor Laws, and I recommend particularly to your attention the 40 odd pages in Book IV in which he analyses the effect of charity, and discusses different plans for improving the condition of the poor. He came to highly unpopular conclusions about the effect of measures adopted by individuals, local authorities and governments for the relief of poverty. What would he think about the enormously greater efforts which are being exerted today on a global scale?

Although most of his major premises have been undermined by our increasing control over births and deaths his first basic proposition is still valid: the reproductive urge in human beings is so strong that there is an inexorable tendency for numbers of people to exceed the means of subsistence. Of course Malthus defined means of subsistence almost exclusively in terms of food, but had he been alive today I feel confident that he would have extended his definition by means of the 2000 year old text "Man does not live by bread alone." He would have included the air we breathe, the water we drink and the land we inhabit.

But it's pusillanimous - to put it bluntly cowardly - for a lecturer to put forward his own unpopular views as being those which would have been adopted by a man who has been dead for nearly 150 years. I shall put the case on a strictly personal basis. Like many people in this Hall, my wife and I have contributed to every appeal made by the Save the Children Fund and the Freedom from Hunger Campaign; and I have not the slightest doubt that we shall continue to do so. Charitable actions such as these undoubtedly stem from a complex of causes - not least the sense of guilt that we are the affluent few among the poverty stricken majority. But whatever the stimulus, reason tells me that we are guilty of treating symptoms not causes; that we are contributing to overpopulating a planet which is already overcrowded with the human species. Surely for the preservation of the race there is one cause above all others to which we should subscribe viz., the support and extension of every known means and the search for new means of reducing birthrates first till they balance death rates and then till death rates exceed them and bring world population into balance with the environment. So complete a change of emphasis is clearly impracticable in the short term, but I know where my responsibility lies, and I hope that I am also persuading you. It lies in pressing for the allocation of as much as possible of any international aid fund to the reduction of birth rates in the developing country for which aid is being sought.

Mr. Chairman, as this address took shape I realised how inadequate and misleading was the title I had chosen. I think you will agree that I have been considering not the agricultural but the human dilemma, the human dilemma of which the agricultural and medical dilemmas form a substantial part.

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