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Introduction

During the last few decades concern has been increasingly expressed about the growth in the number of people in the world and questions have been raised about whether the resources that we can muster to increase the production of food and other essentials on which man depends are sufficient to keep pace with a burgeoning humanity. In the early 1970s the reports by the Club of Rome, in which mathematical methods of dynamic modelling were used to elucidate the relations between population growth, industrialisation, the use of natural resources and pollutional effects of man's activities, suggested that, ultimately, catastrophe was inevitable (Meadows *et al.*, 1972; Mesarovic and Pestel, 1974). At this same time, however, there was a far more immediate concern about the food supplies of the world. In 1971, 1972 and 1973 a combination of poor harvests in each of the major grain-producing areas of the world, combined with the policy change made by the government of the United States of America to reduce its reserve stocks, led not only to increases in grain prices, but to a realisation that the world was critically dependent on each year's harvest. The increase in price had devastating effects on poorer countries which of necessity had to import grain to feed their peoples. The World Food Conference was called by the Food and Agriculture Organisation (FAO) of the United Nations in November 1974 to discuss this serious and immediate problem. At its end the 127 member states, who for the most part were represented by their heads or senior ministers, proclaimed that 'Within one decade no child will go to bed hungry, no family will fear for its next day's bread and no human being's future and capabilities will be stunted by

malnutrition.' No doubt the participants believed that this goal could be reached by 1984. Plainly, it has not. Illustrative are events in Ethiopia, Somalia and other countries in North Africa and East Africa. In 1973, and contributing to international concern, there was famine in Ethiopia following the failure of the long rains of the previous June to September (Miller and Holt, 1975). Now, a more prolonged partial failure of the rains has taken place and again, ten years later, famine has taken a toll of life. Furthermore, there is no reason to believe that in many of the less well developed countries of the world the supplies of food per head of the population is any greater than it was a decade ago; indeed in many it is less.

The statement made at the end of the World Food Conference can perhaps best be interpreted, either as one of hope or one of resolve, and it was brave to make it. That these hopes have not been fulfilled or the resolve translated into an accomplishment is sad. The failure, however, does focus attention on the difficulties that surround the vast problems of the relationships between the numbers of mankind, the food and other essentials that people require and the resources on which the production of these essentials depend. In the chapters which follow some of these problems are described together with the ideas of many who have studied them and suggested possible solutions. Finally, my views are given about what currently seem to be the most sensible courses of action to follow in seeking ways to achieve, not simply a freedom from hunger but also a more equitable world.

Inevitably, the approach adopted involves the making of predictions about what might happen in the future if particular courses of action were to be taken or if present courses were to continue unchanged. The reliability of such predictions warrants thought. Most predictions entail an extrapolation from past experience. However well summarised or generalised this experience may be, it is not infallible and extrapolation is necessarily fraught with error. This is particularly so in the biological and social sciences which are those which are largely our

concern. Identification of all the determinants and their interactions is rarely complete and freedom from extraneous factors seldom attainable. Thus even the most plausible and seemingly well-founded hypotheses lead to predictions that have an intrinsic uncertainty.

A more relevant consideration concerns how predictions should be used. When, at some future time, we look back we will discern but one past, whatever the way in which we might then interpret it. It must follow that there can be but one future. The current value of forecasts of that future resides not so much on their precise prediction of what will occur as on their prediction of what might occur. Consideration of these possible futures allows us to take action so to avoid any adverse consequences that might ensue. Thinking about the future through the formulation of predictive hypotheses can thus prompt action and change thought. I imagine – but do not know – that many of the latter-day Cassandras who predict doom and destruction for mankind are well aware of this constructive aspect of future studies. They may also think that the more frightening the vista of the future they present, the greater will be the reaction and the more forceful the action to avoid what they predict. I have attempted to avoid overstatement of the seriousness of our current predicament; it is already serious enough.

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The numbers of people

MALTHUS

Any discussion about the growth of the population of the world must begin with Thomas Robert Malthus. It was the rejection of a then current view about the future that prompted Malthus to write his famous essay which he published anonymously in 1798. His purpose was to refute what he regarded as an unwarranted idealism about the perfectibility of human society, an idealism that probably had its roots in the revolution in France. The title of the essay indeed reflects this underlying purpose and is: *An Essay on the Principle of Population as it affects the Future Improvement of Society, with Remarks on the Speculations of Mr Goodwin, M. Condorcet and Other Writers.*

In the essay Malthus attempted to explain the apparent stability or, at the most, the slow growth of human populations and used the 'principle' he formulated as the basis of a critique of the idealistic hypotheses. Malthus had been a student at Jesus College, Cambridge, where he had studied mathematics and he presented his principle in these terms. He began by stating his postulates: 'first that food is necessary to the existence of man and secondly that the passion between the sexes is necessary and will remain nearly in its present state'. He then stated: 'Assuming these postulates as granted, I say that the power of population is indefinitely greater than the power of earth to produce subsistence for man. Population, when unchecked, increases in a geometrical ratio. Subsistence increases only in an arithmetical ratio.'

One might immediately cavil at Malthus' logic. His postulates

do not lead to his conclusions; he simply states his principle as his opinion. He continued, however, and here he displayed the customary condescension of the mathematically minded: 'A slight aquaintance with numbers will show the immensity of the first power in comparison with the second.' Malthus then added that to achieve stability of population in these circumstances 'implies a strong and consistently operating check on population from the difficulty of subsistence'. He identified this check as twofold; first a positive check 'which in any degree contributes to shorten the natural duration of life' and second a 'preventative check' which included all those factors which prevent human birth. And, finally, to clinch the argument and to point his attack on Goodwin and the idealists, Malthus wrote: 'it is difficult to conceive of any check on population that does not come under the description of misery and vice'. While Malthus gave some examples of these positive checks to illustrate his thesis, Grigg (1980) has pointed out that none of them related to the curtailment of reproduction by insufficiency of food. This is true not only of his original essay of 1798 but also of the more extended account which he wrote in 1803 and which went through four editions.

THE EARLY CRITICISM

The kernel of Malthus' principle has been given through quotations from his book largely because there are few works which have been so extensively misinterpreted. For example, in a Cabinet Office paper concerned with the transfer of resources to the countries of the developing world (1976) it was stated that 'unless transfers take place on a scale many times greater than at present, the effective check to world population will be the Malthusian trilogy of war, pestilence and famine'. Malthus' primary checks were two, the positive check and the preventative check, although in a later work *A Summary View of the Principle of Population* (1830) one can discern three secondary ones – vice, misery, and moral restraint. Certainly he did not regard

three of the four horsemen as the checks involved. Flew in his essay on Malthus (1970) gives other examples of misinterpretation; some of these are such that the views attributed to Malthus are the antithesis of those which he expressed so clearly in his work.

In the early part of the nineteenth century, however, Malthus' essay had clearly been read and understood. It caused an immense controversy. This controversy largely surrounded the final phase of his overall argument, namely that in the last analysis human populations are controlled by misery and vice. What Malthus had done was to state in logical terms a fatalism and a pessimism which effectively absolved the ruling classes in England from any responsibility for the ever-increasing numbers of the poor. He had attacked the emerging idealism and liberal ideas as exemplified by the Poor Laws and he stated quite categorically: 'Hard as it may seem in individual instances, dependent poverty ought to be held disgraceful. A stimulus seems to be necessary to promote the happiness of the great mass of mankind and general attempts to weaken this stimulus, however benevolent its apparent intention, will always defeat its own purpose.' As J. M. Keynes expressed it in an address on the centenary of Malthus' death: 'the principle provided a powerful intellectual foundation to justify the status quo, to ward off experiments and to keep us all in order'.

The first criticisms, even allowing for the freedom of expression of the time, were vituperative and malicious. Cobbett, the political and agricultural commentator, wrote: 'I have during my life detested many men; but never any one as much as you . . . No assemblage of words can give an appropriate designation of you; and, therefore, as being the single word which best suits the character of such a man I call you "Parson", which among other meanings includes that of Borough-Monger' (Cobbett, 1819). It was, no doubt, this passage that in after years earned for Malthus the soubriquet, 'the gloomy clergyman', and for the corollary to his principle, namely that population equilibrium is only achieved at the expense of misery and vice, the term 'the dismal

theorem'. William Hazlitt, the essayist, in a very long critique of Malthus published in 1825, put forward as a base for ridicule a second corollary to the principle, known as 'the utterly dismal theorem'. This corollary is that any increase in the level of food production in the world must increase the total sum of human vice and misery because population will inevitably increase until Malthus' checks become operant.

Much of the initial reaction to the essay was, however, fragmented and more concerned with the political consequences of Malthus' views in relation to the depression which followed the Napoleonic wars. Many aspects of this early debate were summarised by Smith (1951). Later, more polished rebuttals appeared and these attempted to refute Malthus' principle argument, but most of these have not survived in terms of an assimilation into modern thought. In 1830 Sadler published an enormous work with the incredible title: *The Law of Population: A Treatise in Six Books; in Disproof of the Superfecundity of Human Beings and Developing the Real Principle of Their Increase: in Two Volumes*. In this Sadler stated his own law, namely: 'The prolificness of human beings, otherwise similarly circumstanced varies inversely as their numbers.' He indeed thought that urbanisation would result in a reduction of population and that a reduction in the rate of increase in the numbers of people 'is affectuated not by the wretchedness and misery but by the happiness and prosperity of the species'. Doubleday (1847) went even further. He postulated that fecundity would diminish with the development of individual talents. He wrote: 'Most of the flat-chested girls who survive their high-pressure education are incompetent to bear a well-developed infant and to supply that infant with the natural food for the natural period.' Education, and particularly high-pressure university education would surely solve the Malthusian paradox. These views expressed by Sadler and Doubleday in some ways anticipate those accepted in the twentieth century in support of the so-called demographic transition theory which will be discussed later.

The early socialists were obviously in considerable opposition

to Malthus' views for the reasons already given, and they also attacked the man for lack of originality. Marx accused Malthus of plagiarism stating that he had done nothing more than cobble together the ideas of others including those of Robert Wallace (1753), Joseph Townsend (1786) and James Steuart (1767). Marx could have been even more scathing for Aristotle had expressed doubts about population growth in relation to land area centuries before. It might equally be argued that Marx himself had been guilty of borrowing ideas for the accusation he made was first put forward by William Hazlitt in a letter entitled 'On the originality of Mr. Malthus' principle argument'. In this he commented on Wallace's contribution. The publications of Townsend, Wallace and Steuart had certainly predated that of Malthus; and the accusation would have been justified if Malthus had not acknowledged an indebtedness. He wrote that his principle 'has been advanced and applied to the present subject, though not with its present might or in the forcible point of view by Mr. Wallace, and it may have been stated by many writers I have never met with'. Wallace had indeed reached Malthus' conclusion and so too had James Steuart Denby.

JAMES STEUART

James Steuart's contribution is particularly interesting. Steuart was a Scot, educated in Edinburgh and a Jacobite. He was not at the final battle on Culloden Moor since, at the request of Lord George Murray, he was attempting to bring about a French invasion of England in order to relieve the pressure exerted by General Wade's forces. After the defeat he was exiled to France although he escaped the Attainder. He was only pardoned in 1772, five years after publication of his work. Steuart had certainly anticipated Malthus for he wrote: 'The numbers of mankind must depend on the quantity of food produced by the earth for their nourishment, from which as corollary: That mankind have been as to numbers and must ever be in propor-

tion to the food produced; and that food will be in the compound proportion of the fertility of the climate and the industry of the inhabitants.'

Steuart did not write well. He was regarded by the Hanoverian English as a traitor; he lived across the Channel for most of his life. It is little wonder that his work was largely ignored. Nevertheless, because of his emphasis on the value of state intervention in economic affairs, he should perhaps be regarded as the first Keynesian, and as Skinner (1966) has pointed out, his work bears comparison with that of Adam Smith who was his contemporary. He certainly predated Malthus in his views about population and its equilibrium and appears to have been a much nicer and less gloomy individual.

MALTHUS' ALGEBRA OF POPULATION GROWTH

It seems highly probable that the ideas which Malthus embodied in his essay were extant at the time he wrote it; certainly he has been given most credit for them. There is no doubt, however, that he was responsible for their expression in a mathematical form and it is pertinent to examine these aspects. In this respect one should heed the comment made by Hazlitt – 'mathematical terms carry with them an imposing air of accuracy and profundity and ought therefore, to be applied strictly and with the greatest caution, or not at all'! Perhaps this remark was the forerunner of other remarks in our own century such as 'lies, damn lies and statistics' or that associated with computer models – 'garbage in, garbage out'; Hazlitt's is certainly more elegantly phrased.

The dynamics of populations has been much studied by theoretical ecologists, as well as by demographers, and their work is apposite to the formulation and extension of Malthus' argument. The basic equation of population studies is:

$$\frac{dN}{dt} = N(b - d - e + i)$$

where dN/dt is the rate at which the population, N, increases with time, t; b is the birth rate; d the death rate; e the rate of emigration and i the rate of immigration, all these rates being expressed per person per unit time. For a population with no migration this reduces to:

$$\frac{dN}{dt} = N(b - d)$$

or

$$\frac{dN}{dt} = r\,N$$

where r is the rate of natural increase (or decrease) in the population. If as Malthus supposed r is a constant, invariant with time for an 'unfettered' population, then the population will grow exponentially, or, as Malthus expressed it, in geometrical ratio, because integration of the equation gives:

$$N(t) = N(t_o)\,e^{rt}$$

This is the first of Malthus' basic relationships: the second will be dealt with later. Mathematically, the integrated equation has some interesting properties. Firstly, not only does the size of the population grow exponentially (geometrically) but so too does the number added in each interval of time. Secondly, and not so immediately obvious, the last term is less than the sum of all previous terms. Thus if we take Malthus' simple geometrical progression, doubling the number in each succeeding interval to give the series 1, 2, 4, 8, 16, 32, . . . etc., the sum of all the terms other than the last is always less than the last term. If exponential growth had occurred since the time of Adam and Eve, then there are more people alive today than have ever lived, or, if one does not accept the implied view of creation, since *Homo sapiens* emerged as a separate species. While this conclusion for exponential growth at a constant rate is mathematically correct, there is much evidence to show that it does not reflect what has happened during the course of history. Cook (1962) calculated