STEADY STATE

"The ecological constraints on population and technological growth will inevitably lead to social and economic systems different from the ones in which we live today. In order to survive, humankind will have to develop what might be called steady state. The steady state formula is so different from the philosophy of endless quantitative growth, which has so far dominated Western civilization, that it may cause widespread public alarm." - Rene Dubos, 1969.

INTRODUCTION

In my introduction I stated that human settlements form an ecosystem and, as such, are subject to the same laws of nature that apply to other ecosystems. Humankind continually comes across limits in every sphere of life. The ultimate peaking and decline of easily accessible high-grade energy fossil fuels and mining of minerals are but some of many limits. A crisis can develop when humankind does not accept there are limits. We currently face a climate change crisis largely due to lack of recognition that there are limits, but we do not face a fossil fuel and mineral crisis. These limits exist and we need to accept them in order for humankind to survive in future millennia. What we now face is a values crisis. Humankind needs to take onboard a values system change to enable a transition from growth to steady state without strife and grief. Everyone should be aware that individual value systems are largely the product of communal values held by the majority of previous generations. A growth philosophy has enabled development of civilisation in the past, but there are now strong signals that we have already surpassed our limits to growth. Further development does not require further growth, and survival with further growth is a physical impossibility. Each and every one of us needs to re-examine their own value system within the context of the necessary transition from growth to steady state. Although humankind has the gift of pre-knowledge of death based on past and present evidence, many do not wish to accept death as a part of life and they block it from their minds. Death is essentially an easy concept to grasp, but a difficult one to accept. The same applies to the concept of steady state. I put forward that because many people associate growth with life, the acceptance of steady state as being a part of the life of an ecosystem, including humankind, will come no easier than acceptance of death as a part of life, and yet the evidence for both is all around us.

SIGNAL OF THE NEED FOR STEADY STATE

In the summer of 1970, Professor Jay Forrester of MIT presented a global computer model to the Club of Rome conference in Cambridge, Massachusetts. This global model which took into account over 100 factors including population, agricultural production, natural resources, industrial production, and pollution, enabled the analysis of the behaviour and relationships of these factors. An international team under the direction of Professor Dennis Meadows was set up to examine five basic factors that determine and ultimately limit growth on our planet. Many different model runs were made based on different inputs of the physical aspects of humankind's behaviour. In all model runs capital and population growth were allowed to continue until they reached some natural limits. The results of the study were published in the book *The Limits to Growth*. When population and capital growth were allowed to find their own level, there was no policy that avoided the scenario of an exponential growth of population and capital followed by collapse. Some policies delayed collapse, but a collapse scenario by the year 2100 and earlier were common to all model runs.

Figure 1 Example of Model of Collapse

In the process of seeking the requirements for global equilibrium, constraints on population and capital growth were each tested separately. It was found that the collapse scenario also applied for these conditions. When simultaneous constraints on population and capital growth were tested, it was found that global equilibrium was achieved. The minimum requirements for steady state were defined as being:

1. "The capital plant and the population are constant in size. The birth rate equals the death rate and the capital investment rate equals the depreciation rate.
2. All input and output rates - births, deaths, investment, and depreciation - are kept to a minimum.
3. The levels of capital and population and the ratio of the two are set in accordance with the values of the society. They may be deliberately revised and slowly adjusted as the advance of technology creates new options." (Meadows et al., 1972, pp 173-4)

The above minimum requirements for steady state in a human ecosystem are equivalent to the conditions for climax in other ecosystems.

The concept of a steady state for humankind is not new. In 322 BC Aristotle (2009) stated:

> "Most persons think that a state in order to be happy ought to be large; but even if they are right, they have no idea of what is a large and what is small state... To the size of states there is a limit, as there is to other things, plants, animals, implements; for none of these retain their natural power when too large or too small, but they either wholly lose their nature, or are spoiled."

The "middle way" in finding the "right livelihood" is one of the requirements of the Buddha's Noble Eightfold Path (Sangharakshita, 2007). The tenet of growth values is found mainly in Western cultures, and Eastern philosophy has much to offer with their view of humankind as being a part of nature as opposed to dominating nature.

John Stuart Mill wrote the following in his 1848 book *Principles of Political Economy*:

> "If the earth must lose that great portion of its pleasantness which it owes to things that the unlimited increase of wealth and population would extirpate from it, for the mere purpose of enabling it to support a larger, but not better or a happier population, I sincerely hope, for the sake of posterity, that they will be content to be stationary, long before necessity compels them to it. … It is scarcely necessary to remark that a stationary condition of capital and population implies no stationary state of human improvement. There would be as much scope as ever for all kinds of mental culture, and moral and social progress; as much room for improving the art of living and much more likelihood of its being improved". (Mill, 1965, p751-4)

In more recent times, John Maynard Keynes, the economist whose prescriptions played a dominant role in directing the global economy out of the 1930's depression, believed that the age of growth was only a temporary one and that in the meantime "foul is useful and fair is not" until we have passed through the growth phase, "the tunnel of economic necessity" (Keynes, 1971)

In 1973, a year after *The Limits to Growth* was published, thirteen essayists associated with the Science Policy Research Unit of the University of Sussex published the book *Thinking about the Future: A Critique of The Limits to Growth.* This book represented a severe criticism levelled against the findings of *Limits to Growth.*

The team was co-ordinated by Marie Jahoda, Professor of Social Psychology at the University of Sussex. The main criticisms of the Sussex team were as follows:

1. There is insufficient data available to construct a satisfactory world model.
2. The Limits to Growth team concentrated on physical limits to growth and omitted to take into account changes in values.
3. That there are strong simplistic technocratic tendencies inherent in Forrester's approach. (Cole et al., 1973)

The general nature of criticism was on points of methodology which the Limits to Growth team itself had pointed out. Some criticisms were on points of accuracy. The general conclusion of the Sussex team was that forecasts of the world's future are very sensitive to a few key assumptions and the Sussex team suggested that the assumptions made by the Limits to Growth team might be unduly pessimistic. The Sussex team concluded:

> "The major weakness of the world dynamics models is that they illustrate the pessimistic consequences of exponential growth in a finite world without taking account of politics, social structure, and human needs and wants. The introduction of an extra variable – man - into thinking about the world and its future may entirely change the structure of the debate which these models have so far limited to physical properties." (Cole et al., 1973, p209)

The main finding of the Limits to Growth team - that unless population and capital growth are constrained, further growth would eventually lead to collapse - was and continues to be unsuccessfully challenged. As Kenneth Boulding stated in the United States Congress House in 1973, "Anyone who believes that exponential growth can go on forever in a finite world is either a madman or an economist."

1976 heralded in the publication of the second report to The Club of Rome - *Humankind at the Turning Point.* Mihajlo Mesarovic and Edward Pestel headed the research team which also used a world dynamics model with the following major structural characteristics:

1. "The world system is represented in terms of interdependent subsystems, termed regions. This is essential to account for the variety of political, economic, and cultural patterns prevailing within the world system.
2. The regional development systems are represented in terms of a complete set of descriptions of all essential processes which determine their evolutionary, i.e.; physical, ecological, technological, economic, social, etc.
3. Account is taken of the apparent capability possessed by the world development system to adapt and change." (Mesarovic & Pestel, 1976, p36)

The computer model used about 100,000 relationships as compared to a few hundred in other world models. The following conclusions were made:

1. "A world consciousness must be developed through which every individual realises his role as a member of the world community........
2. A new ethic in the use of material resources must be developed which will result in a style of life compatible with the oncoming age of scarcity. This will require a new technology of production based on minimal use of resources and longevity of products rather than production processes based on maximal throughput.
3. An attitude toward nature must be developed based on harmony rather than conquest.
4. If the human species is to survive, humankind must develop a sense of identification with future generations, and be ready to trade benefits to the next generations for the benefits to himself. If each generation aims at maximum good for itself, Homo Sapiens is as good as doomed." (Mesarovic & Pestel, 1976, p147)

Prior to the industrial revolution, humankind fed on the abundant source of low entropy in the form of solar radiation. Due to the low availability of this source, early humankind did not develop the technological means of fully tapping this source. The industrial revolution made possible by the tapping of energy sources of high availability brought forth mixed blessings. Now that we have approached and exceeded a number of limits to further growth, we need to use the technological skills that we have developed to assist us through the transition period into a steady state phase of human civilisation. The following sections explore the implications of steady state.

STEADY STATE ECONOMICS

All forms of life are open systems that maintain a state of high order and organisation by feeding on a source of negative entropy - solar energy - which radiates from outside the global ecosystem. Life feeds on the flow of energy from outside and also on stocks of energy from within the global ecosystem. Sustainable stocks of energy available to humankind include net phytomass and biomass of other forms of life which are self-maintaining stocks so long as they are not over exploited. Finite non-sustainable stocks of energy include fossil fuels. Humankind throughout history has utilised the flow of solar energy, sustainable stocks of energy, and eventually also finite stocks of energy to produce exosomatic capital extensions of human bodies which support human life. Exosomatic capital stock for hunter-gatherers included clothing, shelter, and tools. Exosomatic capital stock for modern humankind includes buildings, plant, machinery, and energy converters. The list of exosomatic capital used by modern humankind goes on and on. All exosomatic capital depreciates over time due to the laws of entropy unless further energy flows and stocks are used to maintain and replace this capital.

Investment and Depreciation

In this book I use the terms "inflow", "outflow" and "throughput" to describe the movement of energy and mass flow passing through our economic system. Consider the following bathtub diagrams.

Figure 2 Energy Flow and Stock

The formation, maintenance, and replacement of (exosomatic) capital stock depends upon the inflows of energy and mass flows and outflows by the way of depreciation and waste.

In case (a) the inflows are greater than the outflows as has been during the period of the industrial revolution. Capital stocks increases over time.

In case (b) the inflows are less than the outflows. Capital stocks decline because depreciation is greater than investment in maintenance and replacement.

In case (c) the inflows and outflows are equal and capital stocks are sustained over time under conditions of steady state. Steady state is not a stagnant or static state. Instead, steady state is a stable dynamic state of equilibrium where although the size of a combination of capital stocks remains the same, capital stocks undergo continuous change in the same way that cells in our bodies are replaced over time by different cells. Combinations of capital stocks can undergo continuous changes over time under steady state so long as inflows and outflows of energy and mass are equal.

Compared to ecosystems which self-regulate under conditions of climax, our current economic systems do not have automatic feedback systems which promote and regulate the same conditions of climax. In order to achieve steady state, we need to adopt economic systems which regulate inflows and outflows of energy and mass to ensure that inflows do not exceed outflows.

In steady state there is a direct relationship between the size of our total capital stock and the magnitude of inflow and outflow. An inflow of capital investment is required to balance the outflow of depreciation and waste. The inflow must be sustainable and the magnitude of inflow that is available for offsetting depreciation limits the size of the total capital stock that we are able to sustain. It is in our interests to use capital stock which has low depreciation. In other words, by producing capital stocks that have high durability and which also have a high recycling potential, we are able to maintain a larger total capital stock for the same inflow of investment. Alternatively, we are able to sustain the same capital stocks with a smaller inflow. By using capital stocks, such as transport systems, which are more energy efficient than the systems we currently use, we are able to sustain larger capital stocks or we are able to use the same capital stocks sustained by smaller energy and mass inflows.

Although steady state means a constant level of capital stocks with some fluctuations in the form of dwellings, transport systems, machinery, and goods and services, control of the outflow of energy in the form of depreciation and waste influence the ultimate level of capital stocks as much as does the inflow. As humankind transitions from fossil fuels to fully harnessing solar energy, the flow rate of solar energy and the size of the solar "net" or solar energy converter used to capture that solar energy will ultimately set a limit to the possible inflow of energy into our economic system. Maximising energy use efficiency, recycling, and producing goods of long durability with high recycling efficiency potential will all help to sustain an economic system at a higher consumer level than otherwise possible. This would be the case of more with less. The actual level is a moral decision. Steady state cannot make more ample that which is scarce. As Georgescu-Roegen (1971) has pointed out, let S represent the stock of low entropy resources on earth, and R the average annual amount of depletion. The theoretical maximum number of years until the non-renewable stock S is depleted is S/R years. The greater R is, the smaller is the time period for humankind to find alternatives. Both the size of our population and our consumption rate set the pace of depletion of resources which may well represent the life support system of future generations. We have a responsibility to attain steady state as soon as possible. The actual level of steady state is a responsibility further in the future.

One question comes to mind. How do we create new capital stock when there is no surplus capital for investment? Within the context of steady state, the answer lies within the question. When the steady state economy is in balance, new capital stock implies the replacement of old capital stock. If old capital stock is found to be deficient in that it uses energy inefficiently, requires high maintenance and is not competitive, then capital investment is diverted into new capital stock and the old capital stock is allowed to depreciate and is recycled.

A steady state economy allows for replacement of existing capital stock, but unless the population is prepared to temporally forgo their consumption level of life, steady state does not allow for large scale capital investments into new projects. It is of high priority that we set up the necessary low maintenance capital stock now. This especially applies to alternative energy production. At the moment we consume certain goods and services which are unnecessary, waste energy needlessly, and we invest unwisely in projects that rely on and assume a continued growth economy. By re-examining our consumption and investment patterns and by monitoring and controlling inflow and outflow, we can redistribute investments into the type of capital stock that can be more easily sustained in steady state. Some of the investments required may mean allowing some existing capital stock to depreciate. We might also need to accept a lower consumer level of life now. This would allow necessary capital stock to be fully established by the time it is energy cost prohibitive to continue relying on a fossil fuel based economy.

Zero population growth

Population dynamics is the study of changes in population size by tracking births, deaths, and net migration within a given population. The birth rate (b) is the ratio of births per total population for that year and is given in terms of births per 1000 people. A high present-day birth rate is in the order of 50 births per 1000. Prehistoric birth rates are thought to have been around 40 to 50 births per 1000. The death rate (d) is also given in terms of deaths per 1000 population. There is no upper limit on the death rate (d) as war and pestilence both take their toll. However, because we are all mortal, there is a lower limit. With our present-day way of life with sound nutrition and medical care, a low death rate is in the order of 5 deaths per 1000. A low death rate implies that the average life expectancy of the population is lengthened from about 40 years (a death rate of 23 per 1000) to about 70 years.

Population growth is an input-output process just like the capital investment and depreciation process in our economic system. The growth rate (r), the sum of births less deaths (b-d) put into a percentage, describes the rate of natural (excluding migration) increase in population. The following diagram shows an example of a low growth and a high growth population.

Figure 3 Population growth

Pre-agricultural society is an example of a low growth population. The average high death rate would have been only fractionally less than the average high birth rate. India in the 1970s was an example of a high growth population where births exceeded deaths by a large margin. Any quantity which undergoes a constant annual percentage increase is growing at an exponential rate. One way of describing exponential growth is to consider the time period for the population to double. The following table shows the doubling times of the human population. The doubling time is approximately the growth rate percentage divided into 70.

Table 1. Doubling times of the Human Population.

The following diagram shows the age composition profile of Mexico and Sweden in 1970.

Figure 4 Age Composition

The triangular shaped population profile of Mexico in 1970 is characteristic of those countries which have a high birth rate and a declining death rate due to modern age medicine reducing the death rate. Sweden is typical of a country with a low birth rate and death rate. Fertility tends to drop with prosperity. Infant mortality is low so there is no need to over reproduce as insurance towards being taken care of in old age. The trend for nuclear families in developed countries also encourages smaller families.

A burden of a high birth rate and a lower death rate is that the proportion of dependents to those who are economically productive is higher in the undeveloped countries as the following diagram shows.

Figure 5 Dependency Ratio

It is of note that children in underdeveloped countries are required to work before they receive an adequate education which is a necessity to enable a higher technological society to develop.

All self-regulating systems use negative feedback processes to counteract the positive feedback processes which would otherwise drive the system towards self-destruction. This includes nature where ecosystems are prevented from exceeding the carrying capacity via the negative feedback process of succession. In the past, humankind has regulated its populations through the practice of infanticide, war, and the out-casting of the elderly. If humankind wishes to extend its longevity and to die a natural and peaceful death, then humankind has no choice but to regulate its own birth cycle so that the number of births does not exceed the number of deaths.

To achieve Zero Population Growth (ZPG), we need to change our reproductive behaviour. As we decrease our birth rate, the age composition of our population will also change. Populations will continue to grow as females entering the child-bearing age rank produce children at a faster rate than those leaving the child bearing age rank. After a period of one average life time the age composition profile would re-stabilise. The following diagram shows the age profile pyramid for India changing in shape to a stable ZPG age composition profile.

Figure 6 Change in Age Composition to ZPG

The birth rate that we have used so far does not compensate for this change in age composition, so a better indicator of birth trends is the general fertility rate - the number of births per 1000 women between the ages of 15 to 44 years of age. A more meaningful fertility indicator is the average completed family size or total fertility. At the replacement fertility level, each family on an average would comprise of 2.11 children. The extra 0.11 child compensates for the children who do not survive to reproduction age and for those women who do not have children by virtue of choice or infertility.

There are a number of ways to achieve ZPG. One way is to periodically reduce our fertility rate well below replacement level. This would produce undesired effects on the age composition structure within a population and would produce fluctuating population growth and decline in the future. Another way is to reduce the fertility rate down to replacement level and hold it there. Population growth would slow down to zero and the age composition would stabilise over one life time. Demographer Nathan Keyfitz has calculated that if the less developed countries with high birth rates were to achieve a replacement fertility rate overnight, then their populations would continue to increase until it stabilised at about 1.6 times its present size. If the replacement fertility rate took 30 years to achieve, then the final population would be 2.5 times the present size. Developed countries do not face the same increase on their way to ZPG because their total fertility rate is already closer to the replacement level.

To maintain ZPG, a stable age composition is necessary as well as a replacement fertility rate. If a retirement age of 65 is maintained, then the increase in the elderly dependents would be balanced out by the decrease in child dependents. A large part of our budget is spent on education and old age pensions. The elderly could be encouraged to help look after the young in the same way as in extended families. There would be little change in the labour force proportion of the population.

REFERENCES

Aristotle. *The Essential Aristotle*. Knutsford U.K., A & D Publishing, 2009.

Cole, H.S.D., C. Freeman, M. Jahoda, and K.L.R. Pavitt. *Thinking about the Future; A Critique of The Limits to Growth*. London, Chatto and Windus Ltd., 1973.

Daly, H.E. *Introduction* in *Toward a Steady-State Economy*. San Francisco, Freeman & Coy, 1973.

Ehrlich, P.R. A.H. Ehrlich and J.P. Holdren. *Ecoscience: Population, Resources, Environment*. San Francisco, Freeman & Coy., 1977.

Georgescu-Roegen, N. *Bio-Economic Aspects of Entropy* in *Entropy and Information in Science and Philosophy*. Editors L. Kubat and J. Zeman, New York, Amsterdam - Oxford, 1975.

Georgescu-Roegen, N. *The Entropy Law and Economic Process*. Cambridge, Harvard University Press, 1971.

Georgescu-Roegen, N. *The Entropy Law and the Economic Problem* in *Toward a Steady-State Economy*. Editor H.E. Daly, San Francisco, Freeman & Co., 1973.

Keynes, J. M. *Economic Possibilities for our Grandchildren* in *Economic Growth vs. the Environment*. Editor W.A. Johnson and J. Hardesty Belmont California, Wadsworth, 1971.

Meadows, D.H., D.L. Meadows, J. Randers, and W.W. Behrens. *The Limits to Growth*. London, Earth Island Ltd., 1972.

Mesarovic, M. and E. Pestel. *Humankind at the Turning Point*. New York, New American Library Inc., 1976.

Mill, J. S. *Principles of Political Economy*. Editor W.J. Ashley, New York, Sentry, 1965.

Ophuls, W. *Ecology and the Politics of Scarcity: Prologue to a Political Theory of The Steady State*. San Francisco, Freeman, 1977.

Sangharakshita. *The Buddha's Noble Eightfold Path (Buddhist Wisdom for Today.* Cambridge, Windhorse Publications, 2007.

Schumacher, E.F. *Small is Beautiful*. London, Sphere Books Ltd., 1977.

FURTHER READING *** to be added