PROJECTIONS OF GLOBAL CARRYING CAPACITY

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Keywords: Carrying capacity, optimum population, population pressure, renewable resources, resource exploitation, economic development, fossil fuels, hunter-gatherers, ecological sustainability, cereal grains, consumption

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Summary

The term carrying capacity is applied largely to animal populations as the maximum number of individuals in a particular species that can be indefinitely supported by the resources in a particular area. In animal contexts the carrying capacity is determined by the amount of food available, the number of predators, and the rate at which the environment can replace the resources that are used by the population.

In applying this concept to humans there are two differences. First, human beings have the capacity to innovate and to use technology and to pass innovations on to future generations, so they have the capacity to redefine upward the limits imposed by carrying capacity. Second, human beings need and use a wider range of resources than food and water in the environment. Hence, human carrying capacity is a function of the resources in an area, the consumption level of those resources, and the technology used in exploiting them. Therefore, there is a great deal of difficulty experienced in operationalizing or measuring human carrying capacity globally or regionally.

In considering human carrying capacity, it is important to consider the reality of world population growth. The global population at the turn of the twenty-first century was 6 billion, and UN projections suggest that the world's population will stabilize at less than 11 billion in the year 2200. Hence the world is facing the challenge of feeding 80% more people in a 200-year span. One of the most useful aspects of the concept of human carrying capacity is that it draws attention to a reduction in its capacity to support people.

The outlook for producing sufficient food to feed the world's growing population is an

optimistic one. However, this assumes that distribution of food between countries is improved, environmental food production continues to increase, constraints are respected, sustainable production methods are used, and rates of population growth continue to fall.

Estimates by experts of global human carrying capacity range from 2 billion people to 300 billion people. The value of the concept remains the fact that it points to the pressing need to stabilize global population growth and to the disastrous consequences of adoption of nonsustainable uses of the environment.

1. Introduction

The term carrying capacity was largely developed to apply to animal populations, although it has subsequently been used in some quarters to apply to the human population of the world, individual countries, and regions. Stated most simply, it is the "maximum number of individuals in a particular species that can be indefinitely supported by the resources in a particular area."

In most animal contexts the carrying capacity will be determined by the amount of food available, the number of predators, and the rate at which the environment can replace the resources which are used by the population. Figure 1 presents a simple model whereby the numbers of animals in a particular area increases slowly initially but then quickly as it approaches the carrying capacity, and thereafter will fluctuate above and below that carrying capacity.

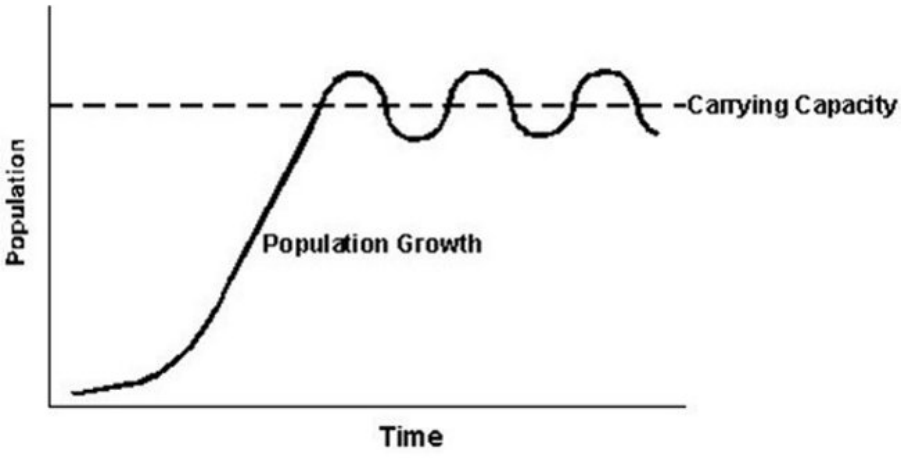

Figure 1. The carrying capacity concept

However, if the resources cannot be replaced or renewed by the environment at a sufficient rate, the carrying capacity of that environment will decline and the population will begin to fall as Figure 2 indicates. Hence a population cannot increase its size *ad infinitum*, and finite environmental resources place an upper limit on the growth of population.

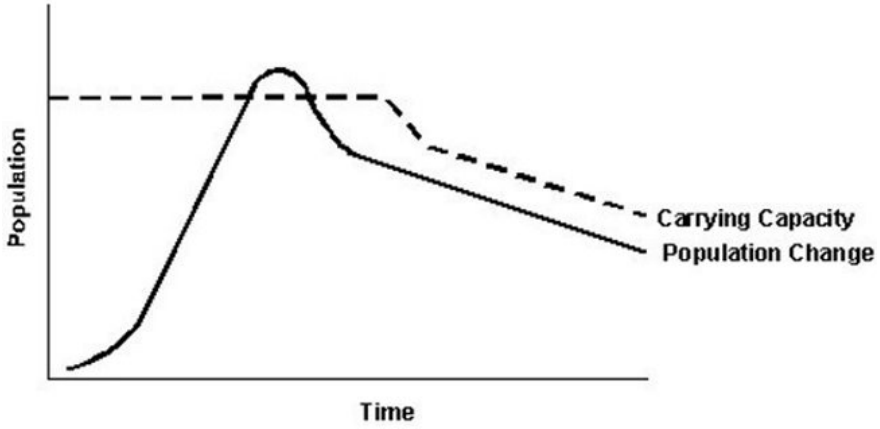

Figure 2. Simple model showing effects of population growth exceeding carrying capacity

Moreover, there is an implication that if the resources are overexploited, their capacity to renew will be reduced, and the carrying capacity will fall. A fall in carrying capacity will be accompanied by a decline in the population.

There have been attempts to extend this concept to apply to humans in addition to other species. A country's human carrying capacity has been defined as "the estimated maximum number of people who can live there indefinitely and be given the opportunity to live long, healthy, self-fulfilling lives." However, there are at least two ways in which people differ from other species when considering carrying capacity concepts. First, human beings have the capacity to innovate, to use technology, and so on, and to pass innovations on to future generations, which animals do not, so they have the capacity to redefine upward the limits imposed by carrying capacity. On the other hand, the actions of animals can only maintain or diminish a resource (e.g., in the case of overgrazing). As Figure 3 indicates, population growth may be associated with an upward redefinition of the carrying capacity because population pressure may be a stimulus for, or be associated with, a redefinition of the resource base due to innovation. Of course people, too, can be the cause of a downward change in the carrying capacity because of human actions leading to deterioration in the resource base.

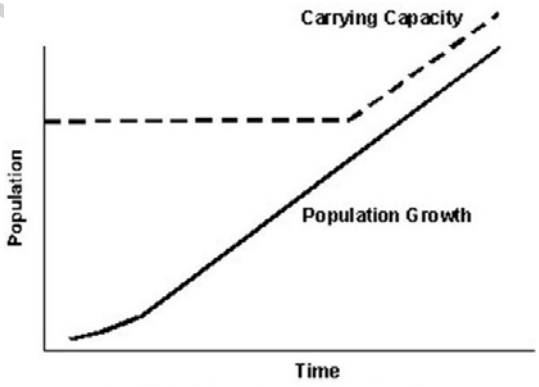

Figure 3. Model of the impact of innovation associated with population growth on carrying capacity

A second important difference about including humans in the carrying capacity concept is that whereas for animals it is possible to determine an upper limit on numbers by the area's capacity to provide sufficient food and water to sustain that number of animals, this is not the case for people. Human populations need and use a much wider range of resources from the environment than food and water. Newman and Matzke have stated:

Conceptually it is useful to think of the environment as a resource complex. It provides a more predictable carrying capacity for populations using naturally occurring resources than it does for humans capable of combining, manipulating and transforming resources. Resources in this view are not fixed in their capacity to support populations but make available materials that can be manipulated in various ways, to provide a wide range of population outcomes.

Placing an upper limit on the numbers of people that can be supported in a country, region, and so on, is determined not just by the resources in that area but also by the technology that is used to exploit those resources and the level of consumption of the resources acceptable to the inhabitants of the area. The latter means that assigning a human carrying capacity to an area is a matter of value dependent judgment. A wide range of human carrying capacity figures have been put forward for Australia whose population in 1999 was 19 million.

1. If Australians would adopt the current consumption levels of Bangladesh, the carrying capacity would be close to 600 million.
2. If they were happy to live at the subsistence level set by the efficiency of photosynthesis, then 1.7 billion people could live in the country.
3. If Australians gave up exporting food, it could grow enough food to support 50 million to 60 million people.

Hence the human carrying capacity of a country can be simplified into the following formula:

$$HC = R \times C \times T$$

Where

HC = Human carrying capacity
R = Resources
C = Desired consumption levels of resources
T = Technology used in exploiting those resources

The number of people that can be supported in an area is a function of the endowment of resources in that area, the quality of life/consumption patterns and levels of the people in the area, and the nature of the technology that is adopted to exploit those resources. Of course technology can produce degradation of resources and hence a lowering of carrying capacity, but technological improvements can also lead to an increase in carrying capacity.

A great deal of difficulty has been experienced in operationalizing the carrying capacity

concept for human populations in particular areas. For example, the development of transportation systems allows resources to be sent from areas of surplus to areas of deficit. Similarly, innovations are constantly making resources out of new elements in the environment, and it is clearly a value judgment as to what levels of consumption are to be used in fixing the carrying capacity. Accordingly, it seems unlikely that a quantitative definition of the human carrying capacity that can be agreed upon by a majority of analysts or commentators can be produced for the human population of a region or for the entire globe. Nevertheless, the human carrying capacity principle is a device that has been of considerable usefulness in:

- drawing attention to the finite limits of the environment globally and in regions
- identifying the pressures placed upon resources by population growth
- proving the unsustainable use of the environment
- drawing out important implications for resource use and environment policy.

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Biographical Sketch

Graeme Hugo, Ph.D., is professor of the Department of Geographical and Environmental Studies and Director of the Key Centre in Research and Teaching in the Social Science Application of GIS at the University of Adelaide. He completed his Ph.D. in demography at Australian National University in 1975 and subsequently took up an appointment at Flinders University in South Australia. He has since held visiting positions at the University of Iowa, University of Hawaii, Hasanuddin University (Indonesia), and Australian National University, and has worked with a number of international organizations and many Australian government departments and instrumentalities.

He is the author of more than one hundred books, articles in scholarly journals, and chapters in books, and a large number of conference papers and reports. His books include *Australia's Changing Population* (Oxford University Press), *The Demographic Dimension in Indonesian Development* (with T.H. Hull, V.J. Hull, and G.W. Jones, Oxford University Press), *International Migration Statistics: Guidelines for Improving Data Collection Systems* (with A.S. Oberai, H. Zlotnik, and R. Bilsborrow, International Labour Office), *Worlds in Motion: Understanding International Migration at Century's End* (with D.S. Massey, J. Arango, A. Kouaouci, A. Pellegrino, and J.E. Taylor, Oxford University Press), several of the 1986, 1991, and 1996 Census-based *Atlas of the Australian People Series* (AGPS), and *Australian Immigration: A Survey of the Issues* (with M. Wooden, R. Holton, and J. Sloan, AGPS).
In 1987 Professor Hugo was elected a fellow of the Academy of Social Sciences in Australia. He has been president of the Australian Population Association and was a member of the National Population Council. He was a member of the International Union for Scientific Study of Population Committee on South-North Migration and two panels of the Australian Research Council.