https://doi.org/10.1038/s41893-022-01041-0

Herman E. Daly (1938–2022)

By Daniel W. O'Neill

Herman Daly, one of the founders of ecological economics, has died at the age of 84. His work questioning the pursuit of economic growth, and articulating the alternative of a steady-state economy, has been foundational to sustainability science.

Herman Daly was born in Texas in 1938. As a child, at the age of eight, he was diagnosed with polio, which left him without the use of his left arm. After seven years of trying every conceivable treatment to regain the use of the atrophied limb, he decided to have it amputated at the age of 15. He would later say, "When you come up against an impossibility it is best to recognise it and switch your energy to good things that are still possible"[1].

As a student at Rice University in the 1950s, he was interested in both the sciences and the humanities. He decided to study economics, thinking it would give him a foot in both. He soon discovered that this was not the case and that mainstream economics instead had "both feet in the air". His life's mission became to change this — to give economics a grounding in both the sciences and the humanities, in particular physics, ecology, and ethics.

One of Herman's first academic articles, published in 1968 and titled "On economics as a life science", made a powerful analogy between biological organisms and economic systems[2]. In the article, Herman drew two diagrams, one for biological organisms and one for economies, showing how they both relied on flows of matter and energy, and both produced flows of degraded waste. This analogy is central to modern research on social metabolism, such as material and energy flow accounting[3]. In the same article, he also proposed that input–output analysis, which traces the flow of money between different sectors of the economy, could be extended to incorporate physical quantities. This approach is now known as environmentally extended input–output analysis, and it is the method used to calculate a wide range of environmental footprint indicators[4].

Herman's incorporation of biophysical quantities into economics drew upon the work of his PhD supervisor, the Romanian economist Nicholas Georgescu-Roegen, who wrote *The Entropy Law and the Economic Process*[5]. Herman translated Georgescu-Roegen's complex ideas into a more accessible form, exploring the implications of the laws of thermodynamics for the economy. He suggested that, "The first and second laws of thermodynamics should also be called the first and second laws of economics. Why? Because without them there would be no scarcity and without scarcity no economics"[1].

But Herman's contributions were not just limited to biophysical concepts. He also made important contributions drawing on ethics and theology. As a Christian, Herman's religious faith was an important part of his life. In his 1973 book *Toward a Steady-State Economy*[6], he proposed the "ends–means spectrum" as a way to prioritize goals and recognize their dependencies. The spectrum ranges from ultimate means (the natural resources that sustain life and all other activity) to intermediate means (the machines and labour that transform natural resources into products and services) to intermediate ends (the goals that individuals and societies aim to achieve) to the ultimate end (that which is desired only for itself, and is not the means to some other end).

Herman argued that economics was positioning itself too narrowly in the middle of the ends–means spectrum, failing to appreciate the scarcity of low-entropy matter and energy and failing to consider what the higher purpose of life might be. It was treating economic growth as the ultimate end, rather than as one means to an end. In Herman's words, "Our refusal to reason about the Ultimate End merely assures the incoherence of our priorities. It leads to the tragedy of Captain Ahab, whose means were all rational, but whose purpose was insane. We cannot lend rationality to the pursuit of a white whale across the oceans merely by employing the most advanced techniques of whaling. To do more efficiently that which should not be done in the first place is no cause for rejoicing"[7].

The ends–means spectrum provides the philosophical framework for much of Herman's work, but it also underpins a lot of other sustainability research that came after. This includes my own work on the provisioning systems that link biophysical resource use and social outcomes[8], as well as Kate Raworth's "Doughnut" of social and planetary boundaries[9].

Herman observed that mainstream economics, which focuses on the circular flow of money between households and businesses, completely omits the natural world. In reality, the economy is not an isolated system, as it is treated in mainstream economics, but a subsystem of the biosphere. All of the resources used by the economy come from the environment, and all of the wastes produced by it return to the environment. To represent this fact, Herman drew a diagram showing a square representing the economy, contained within a circle representing the biosphere, with flows of matter and energy connecting them[10].

Although simple to sketch, Herman's diagram has profound implications. It shows that economic activity can be analysed — not only in terms of flows of money, but also in terms of flows of biophysical resources and social outcomes. Moreover, the finitude of the biosphere implies that there are limits to how large the physical economy within it can grow. Herman argued that we have in fact moved from an "empty world" to a "full world"[11]. The planetary boundaries framework, developed much later by Johan Rockström and colleagues, quantifies the relative size of the square and the circle in Herman's

diagram[12]. It shows that we are now living in a very full world, transgressing 6 of 9 planetary boundaries.

Mainstream economics is primarily concerned with the goal of efficient allocation, arguing that environmental problems can be solved by "getting the prices right". In one of his most-cited articles, Herman argued that the focus on efficient allocation was failing to solve environmental problems because these are the result of the scale of economic activity exceeding ecosystem limits, not of poor pricing within markets[13]. Increasing the prices of certain goods relative to others can reduce the use of bad products relative to better ones, but it cannot address absolute scarcity. Ultimately, there are limits on the resources that nature can provide and the pollutants that it can absorb.

These limits led Herman to develop what is arguably his greatest contribution to sustainability science – the concept of a "steady-state economy"[7]. Drawing on the work of classical economists such as John Stuart Mill, Herman argued in favour of an economy where the goal is qualitative development, not quantitative growth. He defined a steady-state economy as one where material and energy use are stabilized and kept within ecological limits. Fairness is an explicit goal for such an economy: with non-growing resource use, inequality can only be addressed by the fairer distribution of existing resources. Herman discussed a number of the changes that would be needed to achieve a steady-state economy. These include caps on resource use, limits on income and wealth inequality, working-time reduction, re-regulation of international trade, full-reserve banking, a stable population, and new measures of progress to replace gross domestic product (GDP).

Herman was critical of GDP because it does not distinguish between good and bad economic activity. He argued that growth could become "uneconomic" if its costs exceeded its benefits. To assess whether this was happening, he helped develop the Index of Sustainable Economic Welfare (also called the Genuine Progress Indicator), which adds the value of beneficial activity that is not counted in GDP (such as household and volunteer work), and subtracts the cost of harmful activity that we would prefer to avoid (such as crime, pollution, and the depletion of natural capital)[14]. The difference between the two indicators is striking: while global GDP has increased more than threefold since 1950, the Genuine Progress Indicator has flat-lined since the late 1970s[15].

Herman's work was also foundational to one of the greatest debates in sustainability: weak sustainability versus strong sustainability. Advocates of weak sustainability claim that different forms of capital (in particular natural capital and built capital) are substitutable for each other and that sustainability can be achieved if the value of the total stock of capital does not decrease over time. Advocates of strong sustainability claim that substitution possibilities are limited and that sustainability can only be achieved if critical stocks of each form of capital are maintained. Herman argued in favour of strong sustainability, contending that the different forms of capital are complementary. In a highly cited article, he proposed three (now famous) rules for sustainable development: (1) exploit renewable resources no faster than they can be regenerated; (2) emit wastes no faster than they can be assimilated; and (3) deplete non-renewable resources no faster than renewable substitutes can be developed to replace them[11].

Herman received numerous major awards for his work, including the Blue Planet Prize, Heineken Prize for Environmental Science, and a Right Livelihood Award (sometimes called the Alternative Nobel Prize). He also co-authored the most widely used textbook in ecological economics[16]. However, despite these achievements, Herman's work was largely ignored, and sometimes even derided, by his colleagues in mainstream economics. Given the difficult road that Herman pursued in his career, it is all the more remarkable that he was also an extremely kind and humble human being, always willing to see the best in other people, and always willing to engage with anyone who reached out to him. His contemporary, Joan Martinez-Alier, described him as "a good man, 'una buena persona' … [with] no sense of self-importance". Although he helped to found the International Society for Ecological Economics in 1989, Martinez-Alier noted that, "he never cared to be president, or in any way to be in command"[1].

Instead, Herman led with his ideas. These ideas provide the foundation for post-growth research, including degrowth, Doughnut economics, and a well-being economy. But they have also been foundational to research on social metabolism, environmentally extended input–output analysis, planetary boundaries, provisioning systems, alternative measures of progress, and strong sustainability.

The ecological economist Peter Victor recently wrote a biography of Herman Daly, which provides a valuable account of both his life and ideas[1]. Victor argues that while the ideas of most economists become less relevant over time, the opposite is happening with Herman's work. As humanity confronts climate change, rising inequality and ecological breakdown, Herman's ideas are becoming more and more important. His death is a loss for us all, but his ideas will continue to live on in a whole new generation of ecological economists and sustainability scientists.

Daniel W. O'Neill
Sustainability Research Institute, School of Earth and Environment, University of Leeds, Leeds, UK.
e-mail: d.oneill@leeds.ac.uk

Published online: 29 December 2022

References

1. Victor, P. A. *Herman Daly's Economics for a Full World: His Life and Ideas* (Routledge, 2022).
2. Daly, H. E. *J. Polit. Econ.* **76**, 392–406 (1968).
3. Haberl, H., Fischer-Kowalski, M., Krausmann, F., Weisz, H. & Winiwarter, V. *Land Use Policy* **21**, 199–213 (2004).
4. Hoekstra, A. Y. & Wiedmann, T. O. *Science* **344**, 1114–1117 (2014).
5. Georgescu-Roegen, N. *The Entropy Law and the Economic Process* (Harvard University Press, 1971).
6. Daly, H. E. *Toward a Steady-State Economy* (W. H. Freeman, 1973).
7. Daly, H. E. *Steady-State Economics: The Economics of Biophysical Equilibrium and Moral Growth* (W. H. Freeman, 1977).
8. O'Neill, D. W., Fanning, A. L., Lamb, W. F. & Steinberger, J. K. *Nat. Sustain.* **1**, 88–95 (2018).
9. Raworth, K. *Doughnut Economics: Seven Ways to Think Like a 21st-Century Economist* (Random House, 2017).
10. Daly, H. E. *Beyond Growth: The Economics of Sustainable Development* (Beacon Press, 1996).
11. Daly, H. E. *Ecol. Econ.* **2**, 1–6 (1990).
12. Rockström, J. et al. *Nature* **461**, 472–475 (2009).
13. Daly, H. E. *Ecol. Econ.* **6**, 185–193 (1992).
14. Daly, H. E. & Cobb, J. B. *For the Common Good: Redirecting the Economy toward Community, the Environment, and a Sustainable Future* 2nd Edn (Beacon Press, 1994).
15. Kubiszewski, I. et al. *Ecol. Econ.* **93**, 57–68 (2013).
16. Daly, H. E. & Farley, J. *Ecological Economics: Principles and Applications* 2nd Edn (Island Press, 2011).