SHORT RESEARCH COMMUNICATION

Nature in a Macroeconomic Model

Partha Dasgupta [*]

1. CLASSIFICATION OF NATURE'S GOODS AND SERVICES

We humans relate to the rest of Nature in two ways: *we are embedded in Nature, and we harvest from her*. The Common International Classification of Ecosystem Services (CICES) framework can be used to distinguish the two. It is built on the Millennium Ecosystem Assessment (MEA 2005), a ground-breaking work.

1.1. Provisioning Goods

These are the goods that we collect, gather, harvest, or extract from ecosystems. Their regeneration is natural and is a flow (for example, X tonnes of organic bananas per year). However, the goods themselves are stocks (for example, Z tonnes of bananas).

Provisioning goods are Nature's "produce". They are regenerated by Nature over a period of time—it is Nature's "yield". We humans transform these goods into "final products". Using market prices, these goods are aggregated to arrive at the gross domestic product, or GDP.

Some examples of provisioning goods are food, fuel (dung, wood, twigs, and leaves), fibre (grasses, cotton, wool, and silk), fresh water, timber, building materials (soil and gravel), biochemicals and pharmaceuticals (medicines and food additives), genetic resources (genes and genetic information), and ornamental resources (skins, shells, stones, and flowers).

---

[*] Professor, St John's College, University of Cambridge, Cambridge, CB2 1TP, United Kingdom; partha.dasgupta[at]econ.cam.ac.uk. This is based on the notes prepared for a workshop on "Integrating Nature into Macroeconomic Models" held at the London School of Economics, 22–23 January 2026.

Dates: 29 Mar 2026 (submission), 3 July 2026 (acceptance), 31 Jul 2026 (publication)

DOI: https://doi.org/10.37773/ees.v9i2.2008

Published by Indian Society for Ecological Economics (INSEE), c/o Institute of Economic Growth, University Enclave, North Campus, Delhi 110007.

ISSN: 2581–6152 (print); 2581–6101 (web).

1.2. Maintenance and Regulating Services

They maintain and regulate the ecosystem processes necessary for Nature to create provisioning goods. Air-related examples include regulating local and global climate (temperature, precipitation, winds, and currents) and maintaining the gaseous composition of the atmosphere. Water-related services include regulating the flow of water (the timing and magnitude of runoff, flooding, and aquifer recharge), purifying water and decomposing waste, and regulating diseases (controlling the abundance of pathogens such as cholera and disease vectors such as mosquitoes). Soil- and land-related services include controlling crop or livestock pests and diseases, pollinating plants, offering protection against storms (forests and woodlands on land, mangroves and coral reefs on coasts), recycling nutrients, maintaining the ability of primary producers to photosynthesize, and controlling erosion (retaining soil and preventing landslides).

1.3. Cultural Services

They offer non-material benefits. Examples include spiritual experiences and identification with religious values.[1] The diversity of life has, in part, shaped the diversity of cultures. Moreover, various strands of thought across religions attach spiritual significance to flora and fauna. We humans also find aesthetic value in Nature: this is expressed through private gardens, public parks, and protected areas. Ecosystems influence social relationships. Social capital—or interpersonal networks—in coastal fishing villages assume a different form from social capital in nomadic herding and agricultural societies. Further, ecosystems offer humans in close proximity a sense of place and a cultural landscape.

Although cultural services are supremely important for humankind, the first two kinds of services are more fundamental: they are independent of human presence. They evolved and formed the character of the biosphere even before hominids, never mind humans, existed. That is why I focus on them here.

Maintenance and regulating services act upon stocks of natural capital and replenish them. They are measured through *net* regeneration: "augmentation" minus "depletion". Stock in a fishery, for example, is renewed even when births equal deaths; that is, when net regeneration is zero. Numerous processes *within* Nature contribute to this renewal—for example, decomposition of dead material and humans' "waste" products by

[1] It is perhaps more appropriate to trace these experiences and values to Nature, rather than ecosystems, because the latter is a term of recent origin.

fungi. This enables ecosystems to regenerate. Likewise, birds and insects pollinate, helping to create new life, and so on. These processes involve energy flows and material transfers. There is mutual feedback between provisioning goods and maintenance and regulating services. The difference between *drawing upon* Nature for provisioning goods and *depending on* Nature for maintenance and regulating services is all-important here.

These informal remarks motivate the model that follows.

2. A FORMAL MACROECONOMIC MODEL[2]

There are four broad classes of goods that macroeconomic models ought to include: human capital (H), produced capital (K), natural capital (S), and knowledge and technology/institutions (A). Let R be the rate at which natural capital is harvested and r be the intrinsic growth rate. We now construct a bare-bones model of the human economy (the extensions suggest themselves):

Let Nature's regeneration rate be $G(S)$. As the biosphere is bounded, G is a bounded function of S. An augmented quadratic form is simple and usable:

$$G(S) = rS(1 - S/S^*)(S - L)/S^*, \text{ where } \quad r, S^*, L, (S^* - L) > 0 \qquad (1)$$

In eq. (1), S^* is a stable equilibrium of the natural system, and L is an unstable threshold. Thus, S declines to 0 if $S < L$, and it gravitates to S^* if it exceeds L.

Imagine now that economy-wide output, Y, can be expressed as a function:

$$Y = J(S, A)F(K, H, R) \qquad (2)$$

In eq. (2), J is an increasing function of S and A, and F is an increasing function of K, H, and R. It will be noticed that the appearance of S in the J-function represents the idea that the human economy is embedded in Nature, while the appearance of R in the F-function captures the fact that we humans harvest Nature for our purposes.

For brevity, we display the dynamic characteristics of K and S, meaning that we hold H and A to be fixed. We denote time by t and assume it to be continuous.

---

[2] This is based on Dasgupta (2021, 2024).

Let C denote aggregate consumption. Then the economy can be modelled as the dynamical system:

$$\mathrm{d}S(t)/\mathrm{d}t = G(S(t)) - R(t) \quad (3)$$

$$\mathrm{d}K(t)/\mathrm{d}t = Y(t) - C(t) \quad (4)$$

$$Y(t) = J(S(t), A)F(K(t), H, R(t)) \quad (5)$$

In the dynamical system described by equations (1) and (3)–(5), K and S are state variables, whereas R and C are control variables. Positive economics would ask us to study the system under specific behavioural rules regarding the control variables. Alternatively, we could study an optimizing system, in which the control variables are chosen by a decision-maker in light of their objectives.

Ethics Statement: It does not involve human participants, animal subjects, or original data collection, and therefore did not require ethical approval.

Data Availability Statement: No original primary data is included in the work.

Conflict of Interest Statement: The author declares no conflicts of interest.

REFERENCES

Dasgupta, Partha. 2021. *The Economics of Biodiversity: The Dasgupta Review*. Her Majesty's Treasury, Government of the United Kingdom. https://www.gov.uk/government/publications/final-report-the-economics-of-biodiversity-the-dasgupta-review.

Dasgupta, Partha. 2024. *The Economics of Biodiversity: The Dasgupta Review*. Cambridge University Press.