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Annual Review of Economics

Biodiversity: A Conversation with Sir Partha Dasgupta

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Keywords

biodiversity, growth, development, economic theory, inclusive wealth, asset management

Abstract

This conversation with Sir Partha Dasgupta, moderated by *Annual Review of Economics* Editorial Committee Member Tim Besley, focuses on biodiversity and its implications for economic thought and policy. A video of this interview is available online at https://www.annualreviews.org/r/partha_dasgupta_interview.

Tim Besley: Our speaker this evening is Partha Dasgupta, who needs very little introduction. He has been a very important economist in my life and I recall reading his work from an early stage in my career. I particularly remember reading the classic book with Geoff Heal, *Economic Theory and Exhaustible Resources* (Dasgupta & Heal 1979), and his 1982 book *The Control of Resources* (Dasgupta 1982). Lately, he has pursued a line of work leading up to his review on biodiversity (henceforth, the Review) carried out for the UK government, which came out in 2021 (Dasgupta 2021). Exploring these themes will be the major part of our conversation this evening.

But apart from this, Partha has well-known and important work on the economics of innovation, on understanding poverty, on trust, on rights, and on population policy. I am also proud to acknowledge that Partha spent some of the early years of his career at the London School of Economics (LSE) after he graduated from Cambridge, although, sadly for us, he decided to return to Cambridge, where he has remained since.

I would like to begin our discussion by asking you, Partha, how you got interested in issues of biodiversity and what motivated you to explore them. Also, it would be nice to get to know about the framework that you use for studying this and how your thinking has evolved over time.

Partha Dasgupta: It is a pleasure to see you after such a long time, Tim. And it is not only a pleasure, but also personally very moving to return to the LSE for this conversation. The LSE offered me my first job, in 1971, as Lecturer. I remained here for nearly 14 years; it is where I grew up as an economist. The galaxy of stars when I was appointed included Peter Bauer, Terence Gorman, Harry Johnson, Michio Morishima, Denis Sargan, Amartya Sen, and Basil Yamey. Their presence, and the high intellectual standard they maintained in their own work, kept us young economists alert.

My work was very different from the professoriate's, but they must have kept an eye on me, for I progressed rapidly through the ranks. I left the LSE for Cambridge in 1985 not because Cambridge had a better economics department. On the contrary, it was at that time a terrible department, the one ray of light being Frank Hahn. With the help of a recurrent grant from the UK's national funding council, he had kept modern economics alive there with a small revolving group of young economists amid mediocrities who had over the years deployed local academic politics to assume power. The Faculty of Economics at Cambridge has, of course, improved immeasurably since then—and I like to think I have had a hand in bringing in the institutional changes that were required. It is now excellent, but I am talking of 1985. The reason I left the LSE was that when preparing *The Control of Resources*, which you have just kindly referred to, I knew only a smattering of ecology and realized it would be a lot easier to learn the subject in depth if I were at a university with strong departments in the biological sciences.

I wrote the book in response to an invitation in 1978 from the United Nations Conference on Trade and Development to write a paper on the likely implications for world trade if pollution taxes were imposed extensively in the West. As the task was beyond me (I knew too little trade theory!), I wrote instead about the idea that environmental pollution is the negative of Nature conservation; that, for example, when we dump sewage into a river, we damage aquatic life by using the river as a sink for pollutants. The sink is the “good,” while the stuff we deposit into it is the “bad”; and the latter is a “bad” because it reduces the productivity of the “good.” My idea was to use that insight to unify environmental and resource economics, the two having gone in different directions. The paper became a monograph only because I thought their unification could be best illustrated if I provided an account of various ecosystems in turn—fisheries, forests, water bodies, grasslands, the atmosphere, and so on.

As you will recall, the book is a set of staccato-like chapters with a common finding: that each of those ecosystems is a site-specific, bounded, self-regenerative natural asset. I placed human

communities in the ecosystems and identified the kinds of institutional failures that damage lives. The chapters discussed negative externalities at length, both in the small (a factory emitting smoke) and the large (the oceans, the atmosphere). Overuse of a natural asset was shown to be formally equivalent to pollution. But I added one further set of concerns in the book, unusual even today, which was to include the human population as an endogenous variable. The monograph views economic life from the population-consumption-environment (PCE) nexus. That nexus has stayed with me even though that is not where the bulk of the profession views economic life.

Tim Besley: Thanks, Partha. Perhaps you could give us a bit more insight into what influenced you to adopt the PCE approach when nobody else was and when many do not do so even today?

Partha Dasgupta: I arrived at that way of framing economic problems from reading, by sheer chance, an ecology text, *Ecoscience: Population, Resources, Environment* by Paul Ehrlich, Anne Ehrlich, and John Holdren (Ehrlich et al. 1977). That was in 1978. Until then I knew no ecology. The book was for me an absorbing read, but as the authors had avoided mathematics entirely, I tried to understand what they had written by constructing, formally, the dynamics of each ecological system they presented. To my surprise, I found over and over again that the model I constructed had the same structure as the one I had constructed before, which was that of a bounded, self-regenerative capital asset. As we all now appreciate, Nature's processes are a bewildering array of rhythms of varying speed and reach. The models I constructed displayed that, which may be the reason you liked the book. Pretty quickly I also noted from what the authors had suggested that if for some reason an ecosystem's stock were to fall below a threshold, whether in quantity or quality, it would collapse in due course; the processes governing the systems are nonlinear. It was then an easy matter to embed human economies in the ecosystems on my list to offer a picture of life among the rural poor in poor countries.

The latter, incidentally, was a hidden goal; I wanted to shift the language of development economics to the study of what the great economic historian Tony Wrigley later labeled organic economies (Wrigley 2004). I was especially interested in framing extreme poverty in the Indian subcontinent but had not appreciated until then, at least not consciously, that the world's poorest people are asset managers par excellence. They see their lives as being embedded in their local ecosystems, from which they harvest water, fuel wood, fibers, and pharmaceuticals and on which they fish, graze cattle, and grow food. Anthropologists had of course viewed subsistence communities that way for some time, but not mainstream development economists; this was in the late 1970s, remember. My book read life among the rural poor in poor countries as being embedded in site-specific, nonlinear dynamical systems.

Subsequently, in *An Inquiry into Well-Being and Destitution* (Dasgupta 1993), I adopted the PCE nexus to present connections between people's nutritional status and physical stamina and relate the two to their ability to find employment in the formal sector—work that Debraj Ray and I had published some years earlier (Dasgupta & Ray 1986, 1987). The account I developed in the book also explained why norms of behavior among communities in tropical rainforests differ from those in temperate wetlands, why they in turn differ from those in coastal villages, and so on. That led me eventually to study the idea of social capital (Dasgupta 2000a). But before entering the subject head on, I published a paper (Dasgupta 1990), which begins with an exercise in which the rank correlation coefficient is calculated on contemporary data from 46 of the world's then poorest countries to show that democracy is compatible with economic development. I remain proud of that paper, because to the best of my knowledge, mainstream development economists had yet to touch on the idea of social capital and the place of negative freedom in economic life.

Neither book has had any influence on growth and development economics and the economics of poverty; both books sank without a trace. But they remain among my favorite works because

they were on the right track. Moreover, life in small rural communities in poor countries offers a glimpse of the limits on economic possibilities writ large. Until recently, the global economy had remained small relative to the biosphere. The global demand for Nature's goods and services, our ecological footprint, was a lot smaller than her ability to meet it on a sustainable basis. Even when Robert Solow (1956) penned his growth model, he could ignore the biosphere's limits because at that time we were well within those limits. I am talking of the global economy, of course, not local economies. Paleoecologists have traced the demise of those societies that had gone under to their ecological footprint's exceeding the local ecosystem's carrying capacity.

There is no excuse for macroeconomists to continue in the vein Solow set; things are a lot different today. If you plot global GDP, world population, and global GDP per capita from 1 CE to the present, as Angus Maddison and his continuing team have done, you will find each curve to be pretty flat until about 1750, then rising gently, and taking a sharp turn upward from the immediate post-World War II years. Global GDP has grown more than 15 times since 1950, world population has grown from some 2.5 billion to 8 billion, per-capita global GDP has increased nearly fivefold to some 18,000 dollars PPP (purchasing power parity) annually, life expectancy at birth has increased from 46 years to 72 years, and the proportion of people in extreme poverty has declined from 60% to 10%. All this would be unadulterated good news, but for the fact that we have achieved those successes by mining Nature to the point where there is an enormous global overreach into her goods and services. Crude estimates suggest that the ratio of our global demand for Nature's goods and services and her ability to meet that demand on a sustainable basis is 1.7 (an almost certain underestimate), whence the refrain that we need 1.7 Earths to support the current global standard of living (Wackernagel & Beyers 2019). Extinctions of species in the Anthropocene have been occurring at 100-1,000 times the background rate of 0.1-1 species extinction per million species per year. These statistics are a rare example of a point of contact between economics and the Earth sciences, for prominent members of the latter see 1950 as the year we entered the Anthropocene (Waters et al. 2016).

Tim Besley: I have a feeling that this relates to things that you had thought about and worked on from an early stage of your career. Is that right?

Partha Dasgupta: You are right. I had earlier tried to redirect growth and development economics by admitting the influence of a finite biosphere on economic possibilities. My PhD dissertation of 1968 in Cambridge contained a model of the long run in which there were constant returns to scale in produced capital, population size, and a fixed, indestructible factor. My aim was to include population as a policy variable in what would otherwise be a then-routine Ramsey exercise in optimum accumulation of produced capital; but I also wanted to see how the presence of a fixed factor would affect the optimum policy. I first verified that if there is no fixed factor, an optimum policy, when it exists, leads in the long run to unbounded population and unbounded GDP; but then I showed that the presence of the fixed factor radically changes economic possibilities. Optimum policies in the model economy led to a finite population and a finite GDP. Technological progress would overcome some of the biosphere's constraints, but I will discuss later why even if human ingenuity is boundless, it cannot lead to indefinite growth.

I had thought of the fixed factor as land, but that was a mistake. Land can be destroyed through overuse. It is easy to see though that the mistake had no bite; the same finding would have emerged if I had thought of the constraining factor of production as a bounded self-regenerative asset. But even though the paper containing that model was published in a prominent journal, *The Review of Economic Studies* (Dasgupta 1969), it did not have the slightest influence on subsequent writings on macroeconomics of the long run. But life, not infrequently, offers déjà vu moments. I found myself

using the model in my PhD thesis as a template for the Review I prepared for the UK Treasury some 52 years later, *The Economics of Biodiversity: The Dasgupta Review* (Dasgupta 2021).

Tim Besley: Thanks Partha. Perhaps you could articulate the framework that you use and which informed your Review, particularly around the shift from thinking about flows of income toward thinking about stocks of wealth, something that I first learned about in your work, particularly in your joint work with Kenneth Arrow.

Partha Dasgupta: I am happy to do that. It is best to start with the macroeconomic measure in universal use for judging the progress or regress of nations: GDP. It should be a puzzle to everybody that the measure was accepted by macroeconomists without being screened for its normative properties. Two features of the measure make it inadequate, even useless, for normative reasoning in the macroeconomics of the long run. First, GDP is a flow variable (so many dollars per year), which means it can reveal nothing about future possibilities. Second, it does not recognize the depreciation of capital (as the “G” stands for “gross”), meaning that GDP can rise for a long time even while the capital base on which output rests depreciates through overuse. It is true that Martin Weitzman gave a welfare interpretation to net domestic product, or NDP (Weitzman 1976); but he did so by assuming that his optimizing economy enjoys no consumers’ surplus. Moreover, because NDP is also a flow, it can say nothing about future economic possibilities.

But while it is easy enough to criticize GDP as a welfare measure, as many people have, it proved not so easy to know what to replace it with, even for economists. I think the reason is that economists are used to the Hamiltonian calculus in optimization exercises. The Hamiltonian is NDP plus consumers’ surplus. But sometime in 1998, quite unconsciously, Karl-Göran Mäler and I formulated a routine intertemporal optimization exercise using Bellman’s principle (Dasgupta & Mäler 2000). You will recall that Bellman’s value function is well-being across the generations (which is a stock), expressed as a function of the initial stocks of the economy’s capital assets. Mäler and I wanted to create a general methodology for conducting welfare measurement in imperfectly controllable economies.¹ Intertemporal economic models are systems of dynamic equations. The solution to the equations of a given model is a mapping from the set of all possible initial capital stocks into the set of all future economic possibilities. Mäler and I named the mapping a resource allocation mechanism, or RAM. In a fully optimum economy, RAM translates initial capital stocks into optimum economic paths; in Solow’s (1956) model, RAM charts future possibilities as a function of the initial capital stock in a world where the saving rate is constant; and so on. RAM reflects the economic analyst’s understanding of the evolution of technology and social institutions and is the basis on which forecasters project future economic outcomes.

Imagine now that you were to slightly perturb the vector of initial capital stocks. Using the fact that accounting prices of capital stocks are their marginal social scarcity values, you would find that the perturbation to the value function equals the value of the perturbations to the set of capital stocks at the accounting prices in the pre-perturbed economy. The equality says that well-being across the generations and the accounting value of the economy’s wealth—inclusive wealth is the term in use today—are two sides of the same coin: A perturbation to the economy raises the former if and only if it raises the latter. The equivalence theorem provides the normative basis of inclusive wealth.

In the model Mäler and I studied (Dasgupta & Mäler 2000), we included three types of capital stocks: produced capital (roads, ports, buildings, machines), human capital (health, education), and

¹We had been inspired by Arrow & Kurz (1970), who had studied second-best optima in economies with very specific limitations on controllability.

natural capital (ecosystems, subsoil resources). Inclusive wealth in the model is the sum of the social scarcity values of its stocks of produced capital, human capital, and natural capital.² Subsequently, in collaboration with Kenneth Arrow, Mäler and I extended the equivalence theorem to a far wider class of economies, including models with endogenous population (Arrow et al. 2003a,b). We also studied the differences between the concepts of “sustainable” and “optimum” development.

Tim Besley: Thanks Partha. It would, perhaps, be helpful to those who read this if you could lay out the idea of what you refer to as a perturbation in a little more detail.

Partha Dasgupta: Two main interpretations of a perturbation suggest themselves. One sees it as the sheer passage of time. Using RAM, you could judge in which ways the economy’s future, when looked at from tomorrow, will differ from the economy’s future when looked at from today, as changes in policies in the intervening day are anticipated in the RAM. The equivalence theorem says that inclusive wealth is the basis on which the idea of sustainable development should be articulated (as in, Are economic prospects for the future likely to be better tomorrow than what they are today?). The theorem articulates the proposal in the Brundtland Commission Report of 1987 that sustainable development means a development path that meets the needs of the present without compromising the ability of future generations to meet their needs (Brundtland Comm. 1987).

The other kind of perturbation is caused at a moment in time by a small policy change, for example, investment in a small project. Such perturbations are the basis of policy evaluation (as in, Is the proposed project for reviving the degraded wetland worthwhile?). I don’t know if it will come as a surprise to anyone in the audience (it came as a surprise to me), but economists have been applying the equivalence theorem in policy evaluation for decades. In social cost-benefit analysis, the choice criterion is the present value (PV) of the flow of net social benefits. The rule is, if PV is positive, commend it; if it is negative, reject it. But PV has the dimensions of a stock. It is also easy to show that PV measures the change in inclusive wealth that would be brought about today if the proposed project were put into operation (Dasgupta 2004).

In view of the equivalence theorem, I have no explanation for how and why GDP has been accepted by the economics profession as a measure of economic development, nor why the UN Human Development Index (HDI) has such a large fan base among development activists. We should be studying the inclusive wealth (and its distribution) of nations, not the GDP of nations, nor the HDI of nations.³

Shifting attention away from the GDP to inclusive wealth also highlights the fact that economic management is asset management. Ecosystems are capital assets. Biodiversity is a characteristic of ecosystems. If we define it with care (laying stress on functional diversity, not species diversity), we will find that biodiversity enhances the productivity of ecosystems. That has been a major finding in ecology. Although my Review for the UK government is titled *The Economics of Biodiversity*, it reads the subject more widely as the study of asset management.

Tim Besley: How do we get to that in practical terms? Governments are wedded to reporting the latest GDP numbers as indicators of progress, but I know that you would question this way of

²Financial capital and social capital—more broadly, institutions and culture—can be thought of as intangible assets that lubricate an economy. They are reflected in the RAM of the economy being perturbed, and they enter inclusive wealth via the accounting prices of produced capital, human capital, and natural capital.

³HDI is a linear combination of GDP per capita and two basic indicators of human capital: literacy and life expectancy at birth. The index has not been screened by formal normative reasoning; it has been presented ad hominem.

proceeding. What kind of change do you think is needed? Does it require that statistics authorities develop radically new approaches or is it just a case of tweaking what they do now?

Partha Dasgupta: No, it won't be a tweak, nor a move to a complete dependence on inclusive wealth. The idea is not to dismiss GDP from economic reasoning entirely (GDP is useful for short-run macroeconomics management), but to create a parallel system of capital accounts, akin to firms' balance sheets. However, the accounting prices of many forms of natural capital will prove impossible to pin down. It seems to me national accountants should offer a range of estimates rather than point estimates of zero for Nature's goods and services. It may even be that the best that national statistical offices can do is to record whether the quality of currently unpriced ecosystems has improved or has deteriorated. Such information is valuable; it concentrates the public's mind.

There is also the problem of estimating figures for the stocks themselves. Some years ago, when a group of us applied the equivalence theorem to estimate movements in national wealth over time, we chose Brazil, China, India, the United States, and Venezuela to highlight specific features that color the prospects for economic development (Arrow et al. 2012, 2013). We collected data for the period 1995–2004 but were unable to find figures even for national fish stocks. Others have been bolder than us and have gone ahead with an even more limited set of natural assets. Managi & Kumar (2018), sponsored by the United Nations Environment Program (UNEP), have estimated that in the period 1996–2012, on a global scale, per capita produced capital doubled, per capita human capital increased by 15%, but per capita natural capital declined by 40%. Crude though such statistics inevitably are, they confirm what many people have suspected, that the established conception of economic development is hugely flawed. The global economy has accumulated produced capital and human capital in the Anthropocene but has degraded natural capital to an extent that we have been endangering our collective futures. I referred earlier to the finding that the ratio of the global ecological footprint to Nature's ability to accommodate that footprint on a sustainable basis is 1.7 today. That's an enormous excess demand. Because the global economy is in a fire-fighting situation, several of us jointly published a paper (Barrett et al. 2020), in which we identified the economic variables that define the global overreach on the biosphere. Our idea was to point to what national statisticians will need to measure if they are to document the demand we make of Nature. We argued that national statistical offices will have to be opportunistic. Instead of moving immediately to estimating inclusive wealth, they should create natural capital accounts to estimate their countries' ecological footprint. The UK National Statistical Office is active in that direction, and Chile has recently established a Natural Capital Committee connected to the country's Ministry of Finance. China, Costa Rica, and New Zealand are moving in that direction as well. No doubt other countries will follow.

Tim Besley: That actually brings me nicely to my next question, which is about how we link concerns about biodiversity with those about climate change. The two seem related but distinct. Is that right? Many countries have made pledges of the form of net zero emissions by some suitable date—2050 or whatever. Is there something similar that could be done to galvanize public action in the sphere of biodiversity, or is biodiversity just too wide-ranging a goal? And is there a time frame that could also be invoked for this goal?

Partha Dasgupta: You have asked a tough question. It is best to start with a fundamental distinction ecologists have made between Nature's provisioning goods (food, water, timber, fuels, fibers, pharmaceuticals, and nonliving materials) and her maintenance and regulating services, prominent among which are carbon sequestration, nitrogen fixation, nutrient recycling, decomposition of waste, pollination, soil regeneration, purification of water, and maintenance of the biosphere's

gaseous composition.⁴ The former consist of goods that, with human effort and ingenuity, are transformed into the final goods and services that are reflected in the GDP. Provisioning goods are humanity's direct demands from Nature. In contrast, maintenance and regulating services create provisioning goods. We are mostly unaware of the processes that give rise to those services (think of the things that are happening deep in the soils, in the thickness of tropical rainforests, and in the ocean depths), but they are the foundation on which we exist. And because they are several steps removed from our direct experience, we underestimate their significance.

The problem is, there are tensions between our demand for provisioning goods and our need for maintenance and regulating services. When we engage in mining, quarrying, and more broadly in the land-use changes accompanying expansions of crop agriculture, animal farming, plantations, and construction, Nature's ability to supply maintenance and regulating services is diminished. Over a third of Earth's land surface is currently used for crops and pasture. Most new cropland has replaced forests, and most new pastureland has replaced grasslands, savannahs, and shrublands. In the process much biodiversity has been lost. That has correspondingly weakened maintenance and regulating services, including Nature's ability to regulate climate.

There is a further distinction between Nature's goods and services. Although technological advancements have repeatedly shown ways to substitute provisioning goods for one another (fossil fuels replacing timber, solar panels and wind farms substituting for fossil fuels in energy production, and so on), Nature's maintenance and regulating services are complementary to one another: Disrupting one sufficiently disrupts the others. The mutual influence of climate change and destruction of the world's tropical rainforests is an example. The long-standing question of whether labor and produced capital can substitute for natural resources in production (Dasgupta & Heal 1979) refers to provisioning goods, not to maintenance and regulating services. Complementarities among the latter tell us that we are embedded in Nature, we are not external creatures. Nature isn't a house of cards, of course. She is resilient; but we humans are now so clever that we could convert her into one if we chose to do so.

The established economics of climate change (Cline 1992; Nordhaus 1994; Nordhaus & Boyer 2000; Stern 2006, 2015; Acemoglu et al. 2012), including the integrated assessment models that adorn it, grafts an isolated climate system into contemporary models of economic growth and development. It acknowledges that under technologies dependent on fossil fuels, GDP growth brings with it an increasing concentration of carbon in the atmosphere and growing losses in GDP. However, the models assume that indefinite growth in GDP is possible so long as we make a transition to technologies that are not based on fossil fuels.

There are two problems with the models. First, fossil fuels aren't the only source of greenhouse gas emissions. Food production contributes approximately a third of global emissions, with animal-based food products emitting roughly twice the emissions of plant-based food (Xu et al. 2021). With a growing global population (over 9 billion by the end of the century; UNPD 2019), food production would have to increase by some 80% if people are to meet their needs (Balmford 2021). Raising production by that amount at the extensive margin would cause havoc by increasing the rate of biodiversity loss, but that means practices must be found to raise agricultural productivity without destroying the natural capital that is expected to support the increased production.

⁴The pioneering Millennium Ecosystem Assessment (MEA 2005) introduced the distinction. In my Review I dug deeper into the distinction to inform the way we should revise our conception of economic possibilities. Dasgupta (2022) is an afterword to the Review, explaining further some of the more difficult steps I took in developing the economics of biodiversity and responding to comments I have received on the book from political decision makers.

Second, and relatedly, the established economics of climate change supposes that Nature provides us with only one maintenance and regulating service: carbon regulation. It permits analysts to imagine that with only modest investment in the transition to clean energy—say, 2% of global GDP until a net zero economy is attained—we can expect a future of indefinite GDP growth. The presumption is that GDP can grow indefinitely even as humanity dips into the biosphere for its goods and services, transforming what is taken into production and consumption, depositing the residue back into it as waste, but inflicting vanishingly small further pressure on Nature's ability to decompose that waste. This is to imagine that no matter how large the human economy grows to become, further growth would make but vanishingly small further demands on Nature's maintenance and regulating services. The vision is of a human economy asymptotically extricating itself from the biosphere while enjoying unlimited GDP growth. That is the sense in which the established economics of climate change sees the human economy as external to the biosphere. If instead one acknowledges that the human economy is embedded in Nature, the escape route afforded by the idea of asymptotic release from the biosphere does not appear as an option. In my Review I showed why (Dasgupta 2021, chapter 4).

You are right, of course, in pointing to the simplicity of reducing the economics of climate change to ways of controlling a single scalar number, carbon concentration. We do not have that luxury in the economics of biodiversity, but we do have an utterly simple concept on which to rest the subject: productivity of capital. Once we regard ecosystems as capital assets, the economics of biodiversity reduces to a problem (a complex problem no doubt) of asset management. The economics of climate change then becomes a branch of the economics of biodiversity (or of Nature writ large). So, instead of continually finding ways to reduce carbon concentration, as is customary in the economics of climate change, we search for ways to better manage our portfolio of assets in the economics of biodiversity.

People everywhere are asset managers. If you ask rural households in the semi-arid regions of the Indian subcontinent about their concerns, they won't point to a single metric that governs their lives; they will express instead their concerns over whether their irrigation ditch has water in it, whether their cottage is in danger of springing a leak, whether there is enough fodder for their cattle, whether they have sufficient grain in store, whether there are enough shrubs and trees on their land, and so on. The corresponding task before us in managing biodiversity may be immensely hard, but the conception is simplicity itself.

Tim Besley: One key difference would surely be that if consumption is increased in, say, the United Kingdom but leads to depletion of the rainforest in the Amazon, then normally we would just ignore what goes on offshore. By contrast, it sounds like every country in the world should be keeping some account of the depreciation of assets on a global basis, not just within the borders. Is that right?

Partha Dasgupta: That's exactly right. Of course, in an ideal price system, if you have paid for the rainforest depletion when you import the material, you'll have covered yourself. But your question raises deep issues. It is not an accident that the bulk of the world's biodiversity is in the tropics and that most of the world's poorest people live there. Principal exports from those regions are primary products, whose extraction (from mines, plantations, wetlands, coastal waters, and forests) inflicts adverse externalities on local inhabitants. The externalities are not reflected in export prices, meaning that local ecosystems are overexploited; but that amounts to a transfer of wealth from the exporting country to the importing country, from a poor to a rich country. I don't know whether the World Trade Organization appreciates that. Propositions on the benefits of free trade suppose that all goods and services have perfectly competitive markets. The economics of biodiversity is perforce built for a world where markets are missing for many of Nature's services.

The West has for the most part outsourced its needs for primary products. The United Kingdom, for example, has little biodiversity left, but that does not affect its GDP growth rate; the accompanying losses of biodiversity are felt elsewhere. That's why *The Economist* is able to insist that the United Kingdom's environmental laws are hampering GDP growth and wants them to be overridden.⁵

Ecological externalities within regions suggest that countries in sub-Saharan Africa should collectively impose export taxes on primary products. That would ease pressure on their local ecosystems such as rainforests and fisheries and would also be a source of income for them. The World Trade Promotion Organizations held their 2022 conference in Accra. The conference's brief was to find ways to raise GDP in African countries while encouraging companies to move toward sustainable policies. However, the event fielded no quantitative models with which to ask whether GDP can be raised even while protecting the region's ecosystems, nor whether companies in the West would make an ecologically sustainable demand for primary products in the absence of export taxes.

Tim Besley: That brings us nicely to the question of how this change affects how we think about policy. Somebody has to take into account those depreciated assets in that case, and the prices do not exist in the world, because these are not tradable assets. Someone has to be updating the valuations to inform the priorities of policy makers if they are to take these things into consideration. How do you see that working? And is there progress in the sphere of measurement?

Partha Dasgupta: I think it helps to work through specific examples. The aggregate subsidy humanity pays itself to mine Nature (e.g., energy subsidies) is of the order of 4–6 trillion US dollars annually, or some 5–7% of global GDP. That amounts to a negative price for Nature and creates an enormous pressure on the world's ecosystems. The subsidies provide us with a string of incentives to plunder the biosphere, not preserve it. The moral to be drawn is obvious. But perhaps it is exactly because the moral is obvious that there have been few attempts at quantitatively assessing the effects on our consumption patterns if the subsidies were to be removed. On the one hand, an immediate effect would be an increase in commodity prices and therefore lower disposal incomes; on the other hand, reduced taxation would mean an increase in our disposable incomes. There would be huge distributional consequences. Furthermore, technological innovations would veer toward production structures that are less rapacious in their demand for natural capital; and so on. We need a lot more research on these issues.

As to such global public goods as the open seas and tropical rainforests, the first thing to note is that we do not pay for their use. Beyond exclusive economic zones, the former are open-access resources, suffering from the tragedy of the commons. The latter are located within national jurisdictions, meaning that national incentives to conserve them are less than the global incentive.

The oceans have received far less attention than the atmosphere as a sink for our carbon emissions—think of the effort that has gone into estimating the (negative) accounting price of carbon in the atmosphere—but the seas are also vital for our existence. It seems to me there is an urgent need to create incentives to reduce the stresses that are inflicted on the oceans by deep sea fishing, commodity transportation, pleasure cruises, and pollutants originating on land. The standard tools of public economics are regulations and taxes. The former are reflected in protected zones. Recently there has been a call for countries to protect 30% of Earth's land and water.⁶ That has to be applauded, but it has a weakness. Unless restrictions are placed, there will be tremendous

⁵One of the magazine's latest complaints against UK's environmental laws has been in *The Economist* (2022).

⁶COP15 reached an agreement in November 2022 to implement that goal by 2030.

pressure on the remaining 70%. A further problem is that, even though the open seas are, to use a phrase popular in the 1970s, a “common heritage of mankind,” the rents from their use would be enjoyed by users, not by the public. On the other hand, an international agreement would not need an international agency to implement it.

The latter tool, taxation, has the merit that the rents would in principle accrue to us all, which is one reason I advocated it in my Review. However, implementing it requires an international agency. The Review proposed the establishment of an agency with the remit to monitor and charge for the use of the high seas—taxing ocean transportation, deep-sea fishing, and the waste that is deposited into them by nations. That could raise billions of dollars annually, for hundreds of billions of dollars of goods are shipped every year across the oceans in container vessels.

The other reason the Review advocated the taxation scheme is that the rents collected could be used in part to pay nations to conserve the tropical rainforests in their jurisdiction. Currently, the rest of the world complains about the continual destruction of what remains of the world’s rainforests, but little is done about it. Payment for ecosystem services is becoming familiar within nations; the proposal in my Review was to extend such a payment system to the international sphere.

You also asked whether estimating accounting prices for all those goods and services that do not have markets isn’t a tall order. It is. Economics is a hard subject. But much work has already been done to show the way. In the 1960s–1970s, economists developed ingenious methods for estimating the accounting prices of environmental amenities such as public parks, beaches, endangered species, and so on (Freeman 2003). The idea was to infer people’s willingness to pay for amenities from their behavior (travel cost methods) and responses to questionnaires (contingent valuation methods). More recently, attention has shifted to estimating the productivity of ecosystems (Fenichel & Abbott 2014), which is more in line with the central thrust of my Review. The most extensive work on this has been accomplished by young economists in South Asia, under the aegis of the South Asian Network of Development and Environmental Economists (SANDEE), now based in Kathmandu. Haque et al. (2011) have produced an amazing collection of essays reporting field work from which the authors offered quantitative estimates of the externalities associated with shrimp farms (negative), mangroves (positive), atmospheric pollution (negative), forests (positive), and so on. We will need a lot more work like this. Ecosystems are site specific, so we will need a large, variegated collection of studies of even particular ecosystems like mangroves and coral reefs. Estimates from one site would be at best a guide, not the real thing, in a different site. Over time, I am sure economists will devise simple conversion factors to deploy figures in one place for use in another. There is a long way to go.

Tim Besley: An implication of this is that we really do have to raise our game on governance. If we look at progress since, say, World War II, we see huge progress on the provision of education, health care, and other areas where building the state capacity within defined jurisdictional boundaries has turned out to be a very viable model. I am not even sure that we would give the world a very high grade when it comes to delivering on global cooperation on many major issues.

Partha Dasgupta: You’re quite right.

Tim Besley: You hinted at the possibility of a new institution or new institutions that could regulate these large global public goods. How optimistic do you feel about that? Do you think the argument is well established to a point where we can see it being taken forward?

Partha Dasgupta: The proposal in my Review of coupling taxation of the use of the open seas with payment to countries that are home to tropical rainforests has not found enthusiasm among national and international civil servants, on grounds that the world does not have an appetite for such a grand undertaking. Neither the 2021 UN Climate Change Conference in

Glasgow (COP26) nor COP15, nor for that matter the 2022 international meeting in Stockholm (Stockholm +50), raised the issue. At the same time, I would judge from the response of global decision makers to the Review that they agree the world needs to undergo transformative changes if the global overreach in our demand for Nature's services is to be eliminated. At the end of World War II, nations created the World Bank, the International Monetary Fund, and the United Nations and its subsidiaries. The Marshall Plan was designed to lift Europe from ashes, and it helped to do that. Those were transformative steps. But ashes and rubble are visible; the silent and invisible processes that are a characteristic of Nature escape our attention.

Tim Besley: That leads me nicely to my last question and then we will throw it open. As you know, the *Annual Review of Economics* is widely read by practicing economists, young economists, and PhD students looking for good research ideas. I think in mathematics they keep a list of the great unsolved problems that people should be working on. If you were to articulate what the issues are that are receiving insufficient attention in mainstream economics, what would you include?

Partha Dasgupta: I have always felt it is more productive to start with a large question and to opportunistically whittle it down to small sizes, with the hope of joining them eventually to create a finished jigsaw puzzle. The modern tendency is otherwise; we tend to further polish someone else's recently published paper, but that creates far too much path dependence. It is worth remembering that today's journalists and economic decision makers were yesterday's economics students. The mutual influence of academic research and public policy is an underappreciated fact. The synergism between academia, the corporate sector, the media, and government influences the public's expectations of economic possibilities. Too much path dependence has led us astray.

You have asked me for potential research questions. This conversation has been littered with them—for example, estimating the international rents that can be collected from the open seas, the amount of wealth that leaks from poor tropical countries when they export primary products, and so on. So I will focus on a pair of large issues that have been staring at us this evening.

First, we really need to move away from our reliance on contemporary growth and development models. They have dictated the very language we use to discuss economic possibilities and have indirectly supported the ravages we have inflicted on Nature over the past decades. If they are to be useful, macroeconomic models of economic development should no longer ignore the E in the PCE nexus. Two technical chapters in my Review (Dasgupta 2021, chapters 4 and 13) contain a dynamic model that sees the human economy as embedded in Nature.⁷ Beyond formulating it I didn't do much with it, because I don't have the necessary facility. That model, or a suitable modification, should be analyzed and its parameters estimated. If that seems a hard call, just ask where the profession was at in the mid-1950s on quantitative growth models. Economists have done wonders with them, starting with Solow's famous 1957 paper on the residual (Solow 1957). However, contemporary models of growth and development should now be acknowledged to be hugely misleading, not fit for purpose. The trick will be to replicate the technical success of previous generations of growth economists on models that take Nature seriously.

A second large class of issues arises from the P in the PCE nexus. And I want to spend a bit of time on them because economists in recent decades have had an uneasy relationship with demography. Mainstream growth and development economics has encouraged us to think that more human numbers spark more human capital and thus more growth. That belief has been snug with contemporary attitudes toward reproductive rights, about North–South relations, about

⁷Chapter 4 develops the model in the form of economic identities. Chapter 13 presents the conditions a fully optimum path in the economy would satisfy.

sensitivities in discussions between newly ex-colonial powers and countries that emerged from colonial rule, and many other issues. It was an achievement of economic demographers in the 1970s to show that reproductive activity is as amenable to economic analysis as are our consumption patterns (Becker 1981). If we accept that our ecological footprint is creating enormous strains on the biosphere, then we should also admit that human reproduction does not come without adverse externalities. But that is a reason to dig deep into the clashes to test our understanding of rights, it is not an argument for supposing there is not a clash (Dasgupta & Dasgupta 2017, 2022).

Of especial interest is sub-Saharan Africa (Bongaarts 2016), for population growth rates there continue to be very high. Lest there be any misunderstanding, however, I want to stress that per capita GDP of the region is only about 25% of the corresponding global figure and that the region's GDP is 3–4% of global GDP. That means sub-Saharan Africa is not responsible for the global ecological overstretch; but the region's demand from its own ecosystems exceeds their ability to meet it on a sustainable basis, as evidenced by its deteriorating ecosystems (Wackernagel & Beyers 2019). Earlier, I spoke of wealth leaking out of the region via exports. Together with high fertility rates, the pair make a powerful combination. The fertility rate in sub-Saharan Africa is even today about 4.6. (The rate in Nigeria, the largest country in the region, is even higher, approximately 5.4.) This should be compared to the global average, which is 2.4. (The replacement fertility rate is usually taken to be 2.1.) Fertility rates in the region are expected to remain high, and even in 2050 the average rate is expected to be approximately 3. UNPD (2019) projects the region's population of 1.2 billion today to rise to some 2.3 billion in 2050. That is to nearly double in less than 30 years, in a region suffering from dire poverty. Extreme poverty, high fertility rates, and deteriorating ecosystems are a powerful set of ingredients for confining an economy in a poverty trap.⁸

Unless development practices in the region take the PCE nexus seriously, success in one place in the region can be expected to be met by failure in another. The region's problems are frequently read as ethnic conflict or bad governance, or both. But they can also be traced to the stresses created by a rapidly growing population on limited local natural resource bases, acting synergistically to create social stresses. No student of poverty would seem to have estimated the magnitude of reproductive externalities in the region, but it seems to me that without that, sub-Saharan Africa's population will remain outside mainstream discourses on poverty and development.

I have yet to understand why population is a taboo word in official international circles when it is in the self-interest of sub-Saharan Africa to slow down its population growth. Whenever I have asked national and international decisions makers in the numerous Zoom meetings the UK Treasury has organized on my Review since its launch, the response has been “cultural sensitivities.” Whose, though? There is no evidence those sensitivities are reflected in the desires and aspirations of the more than 200 million women in sub-Saharan Africa who have an unmet need for family planning. They are able to control neither birth spacing nor the number of children to have. Meanwhile, the UK government's budget for overseas aid directed at family planning and reproductive health has dropped to near zero. National and international decision makers repeat the now customary talk of the need for female empowerment but confine discussions on the potential means to achieving that goal to female education, a safe subject.

One should be deeply skeptical of that viewpoint. Education, even primary education, involves huge resources and is also especially vulnerable to waste. One of the UN's Sustainable

⁸For a formal model, readers are referred to Dasgupta (2000b). Dasgupta et al. (2023) have studied the implications of this for sub-Saharan Africa for the attainment, by 2030, of the UN's Sustainable Development Goals.

Development Goals is universal primary school education by 2030. The UNESCO estimates that to achieve that in sub-Saharan Africa, the number of teachers will need to increase from 4.6 million today to 6.3 million by 2030.⁹ And the quality of teachers counts, as does their attendance and that of pupils. Moreover, teaching equipment has to be provided, and pupils need to be in a healthy state to be able to learn. Even today, nearly 20% of sixth-grade pupils in the region are illiterate and 30% are innumerate. Some 260 million children and adolescents remain out of school.

The problems Nigeria faces are exceptional even by the region's standard, for population is expected to increase there from some 200 million today to 400 million in 2050. Some 10.5 million children remain out of school, presumably at work in the informal sector. The country's population in prime working age (20–64 years) is projected to increase from about 90 million to nearly 200 million between now and 2050. Nigeria needs to create nearly 4 million additional jobs a year to meet that increase. The unemployment rate is currently about 33%, of which 50% are youths. The ratio of population in the 20–64 age group to total population is expected to rise in the country from a bit over 40% to nearly 60% in the period. Meanwhile, nearly 60% of the population experience modest to severe food insecurity and some 65% of the urban population live in slums. Contrary to what is often aired among development activists, there is no demographic dividend in these statistics (Dasgupta et al. 2022).

The success of Bangladesh in bringing about a fertility transition in what would have been judged by many at its birth in 1971 to be a socially conservative country speaks to the significance of social programs that include family planning and reproductive health. The programs designed there—and NGOs had an enormous presence in them, as in the famous Matlab Thana experiment (Joshi & Schultz 2013, Bongaarts 2016)—have involved providers working with households and village leaders in bringing the facilities to the doorstep. Male partners were involved in the discussions. Female literacy rate in 1971 was only about 25%, but a concerted effort in family planning and reproductive health has brought the fertility rate down from 7 to 2. So, I can only think that it is political, not cultural, sensitivities that are at play in keeping population out of development discourses. And those political sensitivities appear to have been shaped by the sensibilities of decision makers who have a similar cultural background, no matter whether they are men or women or whether they come from the global North or the global South. They have attended the same institutions (in the West) for advanced studies, know one another through conferences and meetings, and want to avoid discussing what may be embarrassing issues for some among them.

Do my impressions come across as overwrought? Perhaps they do, but consider this: At the meeting in Accra of the World Trade Promotion Associations I mentioned earlier this evening, I was invited to deliver the keynote lecture following the conference's opening by Ghana's president. The conference's facilitator, the International Trade Centre (ITC), based at the Palais de Nations in Geneva, prerecorded my speech, as I would be unable to attend in person. Quite by accident I discovered a few days before the event that the organizers at the ITC had erased the last remarks in my lecture, where I had raised Africa's demographic problems. In the event, we agreed I should be removed from the program and my lecture should be cancelled.

Tim Besley: Excellent. Thank you very much. We have a few more minutes so let's see if there are any questions. Who would like to ask the first question from here?

Questioner 1: Let's take a country like Costa Rica, a stock of rainforests that could potentially derive value. Now, when we talk about the climate change issue and the issue of net zero, there is

⁹Readers may consult the Education in Africa topic on the UNESCO website at <https://uis.unesco.org/en/topic/education-africa>.

a lot of conversation about how much will be zero and how much will be net. Therefore there is a lot of resistance in some quarters against actually offsetting one country's missions by planting trees somewhere else. Now, the conundrum that arises as a result is that a country like Costa Rica has a stock. There is a difference between the valuation of that stock and the derived value from that stock, which is a flow. Now, if we don't have that trade of offsets, then the stock is just a stock and a poor country will say, Well, then what do I get from preserving this forest?

I would like to get your thoughts on this distinction between valuation and derived value.

Partha Dasgupta: I have already mentioned the work that has been done on estimating accounting prices of natural capital. So I will respond to the other question. Your suspicions of the ecological basis of net zero are well founded. The fragmentation of ecosystems causes more than proportionate losses in their productivity. To imagine that you can compensate for the loss of a square mile of a tropical rainforest by planting an equivalent amount of biomass on the side of a motorway in the United Kingdom is to hold a climate-fixated view of Nature's services. Tropical rainforests are global public goods, as they harbor enormous biodiversity that benefits the whole world. Costa Rica has enjoyed enlightened governance in recent decades. If experience is any guide from elsewhere, however, we should not bank on it. The world should clearly pay countries housing the rainforests to preserve its forests, but I don't see any political mechanism that can make that happen.

Questioner 2: Professor Dasgupta, it was fantastic to hear about the beginnings of your work on biodiversity, back in the 1970s. Just to signal that your work on economics and biodiversity has real impact, the Grantham Institute at LSE has just finished a study group with about 25 central banks around the world on looking at biodiversity loss and financial stability. That has led about a hundred central banks to recognize that dealing with nature-related risks is part of their business. That's real traction, I think, in terms of your work.

You signaled in your reports the importance of fixing the financial system here, and from your long-lasting reflection on this, I would like to hear some of the signals and advice you would give to people in the financial system about how they can grapple with this issue.

Partha Dasgupta: You have asked a really hard question, so I will only be able to sketch a tentative answer. Although exports of primary products involve wealth transfers from exporting to importing countries, it is not an unalloyed benefit for importing countries. That is because the transfers carry with them risks for importing companies. And that is because they come with increases in the risks to the productivity of ecosystems in the exporting countries. Since my Review was published, directors of investment companies and financial institutions have repeatedly raised their concerns over the financial risks that investors experience because of our ecological overstretch. That's at the heart of your question. It is relatively simple to construct models that quantitatively trace the risks to profits that importing companies face to the risks of ecological collapse in the countries from which they import primary products. Insuring against such risks in the marketplace is not a viable option. In addition to the moral hazard that is inevitably present along long supply chains, the risks are positively correlated (if a wetland is damaged in the exporting country, pollination suffers in neighboring farms). What is needed are incentives for importing firms to protect ecosystems that are upstream in their supply chains. Investment in Nature would be the needed form of insurance.

One member of the Advisory Panel of my Review, the late Sir Roger Gifford, was convinced that maintaining the integrity of ecosystems in their supply chains is sound business practice for companies. Investment in the sources of primary products makes business sense, he told me, if for no other reason than because firms would enhance their reputation among investors. Sir Roger

appreciated of course that a company that makes a unilateral move toward ecological stewardship faces risks should consumers not be ecologically minded; first movers do not necessarily have an advantage. However, there have been examples where companies have enjoyed an early-move advantage by declaring their trade practices to be fair. It is hard to generalize from these experiences. How strongly investors and consumers feel about ethical practices matters.

One way out of their dilemma would be for companies to disclose conditions in their supply chains collectively. Disclosure would be a substitute for missing markets. (The practice of disclosing the contents of the food we purchase in supermarkets is customary today.) A way to do that would be to lobby the government to make disclosure mandatory. For far too long we have heard private companies lobbying governments to ease restrictions on their activities. The economics of biodiversity points to the need for citizens, private companies, and government to work together, and that may mean that companies may want to tie their own hands and ask their governments to make that happen. There are huge gains to be enjoyed by all parties, but the problems besetting collective action rear their heads. Scott Barrett has probed deeply into the issues of collective action companies must attend to if they, for example, wish to reduce financial risks from deteriorating ecosystems in the tropics (e.g., Barrett 2012). Estimating the financial losses from the heightened risks of collapse of assets in their supply chain would be a first step in translating ecological risks into business risks.

Questioner 3: One of the parts of your conversation was aiming at public goods and payment for ecosystem services and you make the case that people can bargain over that. That is very compelling, but it also relies on the fact that both parties have power and are informed about the value of what they are providing. It seems to me that in a lot of cases when we are thinking about deforestation and overfishing, one of the parties doesn't really know the value of what it is providing and has really low bargaining power with respect to the destroyer of the resource, if you wish. Is the argument here that the government should step in more and make people understand the value of the services they are providing? Or is it more about making sure that these groups of people can organize and bargain toward getting better services?

Partha Dasgupta: You are right, of course, but your question would be pertinent even if there were market prices available for an asset you own, for you may be uncertain of its worth to you personally. On top of that, as you say, you would be bargaining with someone whose valuation is unknown to you! But that is life, and it is how negotiations are conducted all the time. Imperfections of knowledge of the value of ecosystems should not be used as an excuse to avoid the issues we have been discussing this evening, especially when there is an urgency in reducing our ecological footprint. My own sense is that it is general ignorance of our deep embeddedness in Nature that has been the bottleneck so far.

Questioner 4: There is a tremendous tendency in many of these debates to say, We more or less understand the theoretical position and if we could control for all of the issues we're talking about, then we'd be fine. Many seem to think that the real problem lies in governments and politics and how open the politicians are. Do you think that actually we need to be benignly dictatorial in order to protect the long-term interests of the grandchildren of the worst off?

Partha Dasgupta: That is a tricky question, but as it is very, very pertinent, I'll have a shot at it. First, citizens in democracies willingly give up certain rights and insist on their governments to exercise dictatorial powers to enforce them. It is a way to enjoy collective benefits. This is bread-and-butter stuff in political philosophy. The economics of biodiversity merely points to a further regime where the coercive powers of the state should be exercised.

However, none of those institutional changes we have touched upon this evening will prove to be sufficient if we are to protect Nature and thus ourselves. It is not possible to devise institutions that can provide us with a complete set of the incentives to protect and promote Nature. That is because Nature is mobile, and many of her processes are silent and invisible. Institutions can work only when our activities are either observable or verifiable. They are necessary if the law and social norms of behavior are viable means of eliminating the adverse externalities associated with our activities. Imposing a fine on environmental damage requires the law to be able to verify not only that the damage occurred but also who was responsible. Likewise, imposing a social sanction on harmful behavior requires that the community can observe that behavior. As institutions have limited reach, restraint must ultimately be exercised by our own will. An urge not to disfigure the landscape should not be prompted by a worry that we would suffer punishment from society; it should be motivated instead by our appreciation that to do so would be wrong, period.

Such self-restraint can be prompted within us only if we develop an affection for Nature's workings, an appreciation of the complexity and mystery of what goes on in the world around us. And that appreciation can only happen in an increasingly urbanized world if we are engaged in Nature studies from our earliest years through our secondary and tertiary education. Our education system is far from there, which is why we need urgently to bring about the required reform. If we are to make peace with Nature, which is to say peace with ourselves, we all need in part to be naturalists.

Tim Besley: Well, it is time to draw matters to a close. What I would take away from your last comment is that, in a way, you are playing a role not only as an economist in all of this but also as a member of civil society, contributing not just as an academic but also by changing opinions. And this can be powerful in changing the world. I think you must be right that the route to change is to have a much wider appreciation of the issues that you have been talking about this evening. I hope in the years to come your Review will be considered a landmark in shifting the direction of policy and thinking.

It has been a real privilege to spend time with you, as ever, Partha. I am sure that everyone else in the room feels the same. Thank you very much for coming.

Partha Dasgupta: Thank you very much.

DISCLOSURE STATEMENT

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