1

Partha Dasgupta's Contributions to Environment and Development Economics

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1.1 INTRODUCTION

Academics don't usually begin their working lives with a grand ambition. They start by writing a single paper—usually, the chapter of a PhD thesis. Then they write another. If they like the work, they keep at it. Sometimes the idea for a new paper comes from the last one. At other times it is inspired by another person's work or the suggestion of a possible collaborator. It may come from reading the newspapers or being eyewitness to an event. When academics collaborate, they combine their ideas and talents. Along the way, they accumulate new technical skills and knowledge. The field also moves forward, and each researcher moves with it, though not always in lockstep; the best move out ahead. Some work turns out to be a dead end. Some may be abandoned at an early stage. But some of it, if a researcher is lucky or unusually brilliant, opens up whole new areas for exploration. Most of the time, a researcher doesn't think about any of this. He just tries to finish the thing he's working on. But when a researcher gets to a certain age, he can look back and see what he has done.

Partha Dasgupta did this recently when compiling the two volumes of his *Selected Papers* (Dasgupta 2010a, 2010b). What he saw was not a collection of papers so much as an evolution in ideas. In the preface to the first volume, he describes his work as being constructed "brick by metaphorical brick," with some papers building on previous ones, resulting in "a growing realization" about his subjects, rather than "a blinding revelation." Recognizing that the best research occurs where conscious ignorance meets the frontiers of knowledge, he comments as much on the results that have eluded him as on what

he has discovered. At the end of the introduction to the first volume he says, "There is a great deal left to be understood." At the close of second he writes, "There is much left to be done."

Indeed. And it really could not be otherwise, because Dasgupta has taken on some of the biggest questions in economics. This volume pushes a little deeper into his research territory, with both conceptual and empirical contributions. All these chapters add to our knowledge, even as they pay tribute to Dasgupta's body of work. In this introduction we map the area studied by Dasgupta and show where the chapters in this volume fit within his landscape.

Much of Dasgupta's work navigates within the wake created by Thomas Malthus's *An Essay on the Principle of Population*. Knowing there must be limits to population growth, what will these be? Malthus's prophecy was gloomy; he thought that the "power of population" would overwhelm "the power of the earth to produce subsistence for man." Dasgupta's perspective is more refined; he sees that nature's abundance has bounds, but that human institutions can both limit population (through, for example, an evolution of norms) and ease resource constraints (by means of substitution and especially technological advance—the subject of Joseph Stiglitz's main contribution to this book). At the same time, Dasgupta doesn't believe Nature's constraints are endlessly mutable or that effective institutions can be counted on to spring up from nowhere just when they are needed. He has been critical of the assumption underpinning many economic analyses that growth (specifically, total factor productivity) can continue without limit, noting that over the very long arc of human history the rate of growth in per capita income has only squeaked above zero. He doesn't fear that we will run out of resources; he fears we will undermine the ecological systems that support the human enterprise. (In this volume, Kenneth Arrow, Paul Ehrlich, and Simon Levin similarly emphasize "how deeply intertwined are the problems of improving the welfare of humanity, especially the half in need of 'development,' ... and the problems of maintaining ... crucial [ecosystem] services.") The neglect of nature in modern economic analysis, particularly in development economics, has long been a thorn in Dasgupta's side.[1]

Other work by Dasgupta is more in the tradition of Adam Smith's *An Inquiry into the Nature and Causes of the Wealth of Nations*. Indeed, the title of Dasgupta's own magnum opus, *An Inquiry into Well-Being and Destitution*, teasingly invites the comparison. But whereas Smith was interested in the "civilized and thriving nations," Dasgupta's focus has been on the societies Smith ignored—the people we now call "the bottom billion." Smith wanted to explain how the rich countries became rich. Dasgupta aimed to explain

[1] See especially Dasgupta (1982) and the introduction to Dasgupta and Mäler (1991).

"the circumstances in which people are born, and the manner in which they live and die in rural communities of poor countries" (Dasgupta 1993: viii). But if Dasgupta's concerns are different, his approach resembles Smith's own. Smith wrote on the *wealth*, not the income, of nations. Today's convention is to look at income as a measure of economic success and income growth as a metric for economic progress, but Dasgupta has restored wealth's place of importance in economic theory. In *Human Well-Being and the Natural Environment*, Dasgupta shows that wealth (specifically, *inclusive* wealth) is the correct indicator of "sustainable development," not Gross Domestic Product (GDP), or Net National Product, or even Green GDP. His conceptualization of sustainable development reflects the concerns that were uppermost in the minds of the Bruntland Commission when they popularized the term. It also reflects the concerns Dasgupta has long brooded over, including the loss of ecosystem services ("inclusive" means inclusive of natural capital assets that may be un-priced in the marketplace).

There aren't many economists whose contributions can be compared with giants like Malthus and Smith, but there is no economist in the modern era like Partha Dasgupta. In addition to the work already mentioned, Dasgupta has made seminal contributions to game theory, industrial organization, voting and social choice theory, science and research-and-development (R&D) policy, social capital, and project appraisal. In this Festschrift, however, we celebrate the subject that has been Dasgupta's consuming passion, the subject he has made his own: the poverty-population-environment nexus.

1.2 OVERVIEW

Partha Dasgupta's abiding interest has been with the human condition, something he calls *well-being*. His analyses embrace all of humanity, but his greatest concern has been with the poor, especially the abject poor—the illiterate, the undernourished, the landless, and the destitute. In his *Economics: A Very Short Introduction*, Dasgupta (2007a) compares the lives of two (fictional) 10-year-old girls, one born in the United States and the other in Ethiopia. As children, these girls are indistinguishable; they both like to play, to gossip, and to eat a good meal. Their parents are also alike; they love their daughters, and will do all they can to give them a good start in life. And yet the well-being that can be attained by these two girls differs dramatically, thanks to the contrasting circumstances of their births. One enjoys great opportunities; the other faces harsh constraints.

Neither girl can change this. The best each girl can do is to make use of the opportunities available to her, and to adapt to, and cope with, the constraints she must face. Some people are of the mind that, with effort, thrift,

and determination, anyone can achieve success in life. These are admirable personal traits, for sure, but, as Dasgupta argues, what a person can make of her life depends on much more than her character.

From the perspective of the societies into which these girls are born, however, the circumstances of their births are not entirely fixed. The opportunities available to these girls can be widened. The constraints they face can be eased. The inheritance of the girl born in Ethiopia, in particular, can be improved. There is a role for government; public investments and policies can make a difference.

Some development specialists see poverty in its many expressions as requiring an overarching and simple remedy—"structural adjustment," meaning market-liberating reforms. Others are more inclined to prescribe concrete remedies for specific ills: to reduce population growth, make contraception available; to supply clean water, drill more boreholes, and so on. Dasgupta looks at both the macro condition (the extent of poverty, say, or the depth of the water table) and its micro-behavioral causes. He shows that liberalization won't help the destitute if they are caught in a poverty trap, and that improved access to contraception won't reduce population if couples are *choosing* to have more children.

It is a habit and convenience for economists to look at economic life as being lived at or near an optimum (thus, for example, the terms "first best" and "second best"). Dasgupta has always looked at its fuller spectrum. He has, in particular, shown how the lives of people can be improved even in the most dysfunctional of states. This was a key contribution of his earliest work on project evaluation (Dasgupta, Marglin, and Sen 1972). It remains a central feature of his latest work on measuring intergenerational well-being (Dasgupta 2001).

A defining aspect of Dasgupta's work is the respect he shows for the common man, woman, and child. The poor in his work are neither feckless nor irresolute. Nor are they saints. He sees them as people who have the same virtues and faults as the rest of us, only lacking the advantages many of us are lucky to have. He doesn't think the destitute can change their lot by self-help alone. But neither does he propose as a remedy for their plight that developing countries be given a hand out. More than anything, he sees the lives of the poor and destitute as being bombarded by externalities. He sees these people as facing relative prices that, because of institutional and policy failures, work against their collective interests. He sees that their lives can be improved (e.g., by correcting prices), even in the absence of aid. In fact, aid is rarely mentioned in his work on development. This is just as well for, as the late Elinor Ostrom and her coauthors Clark Gibson, Sujai Shivakumar, and Krister Andersson show in their chapter in this volume, the very provision of aid changes the incentives governments have to develop their economies. Countries can use aid to propel their development, or they can use it to mismanage their economies so as to obtain yet more aid.

Dasgupta often succeeds in ruling out perspectives rather than in identifying a single, pure truth. He knows that a theory can be disproved, when its predictions conflict with the facts, but he also knows that there may be different explanations for the same facts. It is often claimed that people disagree about policy because they have different values. Dasgupta sees things differently. In the introduction to his *An Inquiry into Well-Being and Destitution*, Dasgupta says that he thinks people have different opinions because they have different perceptions about "how the world 'works' "(Dasgupta 1993: 6). They agree destitution is lamentable; they disagree about cause and effect—about *how* the destitute can be helped. More than anything, Dasgupta's research has tried to illuminate these relationships.

Although Dasgupta gives names to the girls mentioned in the opening to his *Economics: A Very Short Introduction*, we can think of these girls not as particular individuals so much as representatives of their respective communities. At the same time, Dasgupta recognizes that communities are more than assemblages of autonomous individuals. People are connected to one another; they have bonds (some of which are mutually beneficial, and some of which are exploitative); they have identities (brother, sister, mother, father, son, daughter, neighbor, clansman, caste member, etc.). Communities have a character of their own. They can sustain different norms; they can display different characteristics of "social capital." These features of a community in turn shape the outcomes that can be attained by the individuals who make up the community—think of the difference a norm such as, "girls should be educated," can make. As well, these features of a society are the product of the behavior of the individuals that comprise a community. Norms and social capital are defined and sustained by *practice*. By combining the insights of an array of literatures, from psychology to sociology, anthropology to political science, and history to game theory, Dasgupta is able to demonstrate not only that communities matter, or that they vary, but that the characteristics (culture) they display are neither inevitable nor fixed. In a phrase, "Social systems have multiple equilbria" (Dasgupta 2005b: S5).

Policies and projects affect many individuals. When we ask if a policy or project is "good," we want to know if it is good *overall*. But to answer this question, we need a measure of society's well-being. What do people care about?

One thing people have come to care about is "sustainable development," meaning "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (World Commission on Environment and Development 1987). The current generation can't guarantee the well-being of future generations, but it can (and, according to this view, is obligated to) try to ensure that future generations have the *wherewithal* to meet their needs. This "wherewithal" consists of the stock of capital assets—knowledge, plants and machinery, an educated population, natural resources, and so on. It also consists of a country's institutions, including its "social capital."

When introduced in the 1980s, the concept of "sustainable development" was given a welcome reception. It seemed to tap into a concern many people had had for a long time. Dasgupta, however, had written about it years before—only he didn't give it a catchy name. His collaboration with Geoffrey Heal, especially their seminal book, *Economic Theory and Exhaustible Resources*, already laid the foundations for how to think about sustainable development. Previously, the economics of exhaustible resources had focused on the mine owner and the market for its ore (Hotelling 1931). Dasgupta and Heal (1979) looked on the extraction of resources as a societal matter loaded with ethical, especially intergenerational, implications. Their book includes an analysis of renewable resources as well, but Dasgupta (1982) subsequently developed this work in much greater detail in *The Control of Resources*, emphasizing the intimate connections between poverty and mismanagement of the environment. After the Bruntland Commission report was published, he developed a more comprehensive theory of the measurement of sustainable development. The theory is now pretty well developed, but Dasgupta continues to work on its implications and relevance for policy.

1.3 NUTRITION

Though Dasgupta starts from the perspective of the individual, he doesn't just take the individual as given; he observes that a person's genetic makeup can depend on events that preceded her birth.

An individual's genetic inheritance is expressed in the embryonic stage. It isn't only nature (DNA) that determines a person's future, but the nourishment a foetus obtains from his mother in the first weeks of pregnancy. A mother's nutritional health can thus cause epigenetic changes that determine the body size and cognitive development of her child—and thus his future prospects. As Dasgupta (2013: 115) explains, "the experiences that shape an adult start even before his birth and perhaps even before his mother's birth."

How might a child's mother have come to lack the nutrition necessary for him to have a good start in life? Famine and undernourishment are both possibilities. Famine more readily attracts our attention; it's an event. The slow grind of malnutrition is a more chronic and pervasive condition, perhaps more resistant to change.

Consider a person so deprived of nutrition that he is unable to exert great effort. As a consequence, his income is reduced. But, having less income, he can now afford less food, making him weaker still, and so lowering his income still further. Even if the circumstances of his birth and childhood were favorable, he is now caught in a downward spiral. Pretty soon he is trapped. To obtain more calories, he needs a higher income, but to acquire a higher income he must first be better fed.

Why do some people get trapped and not others? Is the reason indolence, bad luck, or something else? Dasgupta and Debraj Ray (1986, 1987) analyze this formally. In their model, different people hold different quantities of assets (land) from which they can earn a non-wage income. In the labor market, people are paid efficiency wages. That is, they are paid a wage rate (per hour of input) that minimizes the wage per unit of labor power (a measure of what a person can accomplish in an hour). Labor power is the real input, and it depends on an individual's consumption, especially his nutritional intake. Fitter people make better (more productive) workers. This is where the distribution of assets comes in. People with assets can afford to buy more food at a given wage than the assetless, and so are cheaper (per hour) to hire than the assetless. In a competitive equilibrium, not everyone willing to work at the going wage may find employment. Some people—some of the landless, perhaps, or all of the landless and some smallholders—may find themselves both unemployed and undernourished. "The market" has many virtues, but it cannot necessarily be relied upon to help the destitute.

How *can* the destitute be helped? The essential problem highlighted in this model is the distribution of assets. The obvious policy remedy is thus redistribution. Dasgupta and Ray show that land reform can be transformative, reducing the number of involuntarily unemployed and malnourished while at the same time increasing aggregate output. However, they caution that any old land reform won't do. This is because the people who are made more productive by the reform could displace other persons who were employed previously. Suggested reforms, if they are to be sure to improve matters, must be underpinned by careful empirical analysis.

Land reform isn't a policy advocated by the "Washington Consensus." But the prescription of remedies needs to be preceded by careful diagnosis. Orthodoxy won't do. As is typical of Dasgupta's approach, this model first explains why a situation emerges—why, for example, some people can be malnourished in a land of relative plenty. Only then is it used to explain how matters could be improved. The approach is crucial: unless we understand the mechanisms and pathways that lead to an undesirable outcome we won't make policy recommendations that are likely to make people better off. "Getting the prices right" won't help if the causes of human misery lie elsewhere.

1.4 POPULATION

As noted by Arrow, Ehrlich, and Levin in this volume, critical ecosystem services "are under unprecedented assault as a result of a still rapidly growing human population." Isn't a central problem that there are too many people?

Asking this only begs another question: what is the optimal population size?

One approach to answering this question, Average Utilitarianism, defines the optimum as the population size that maximizes *average* well-being per person. A different approach, called Classical Utilitarianism, defines the optimum in terms of *total* well-being. Which is better? Start with the population that maximizes average well-being. Now add a person to this population. By definition, average well-being must fall. But shouldn't the well-being of the person just added also be counted? If it should be counted, and if this person's well-being exceeds the loss experienced by all the others, then total well-being will have improved by the addition to population. Classical Utilitarianism would thus say that we should add this person. In fact, we should continue to add people until we reach the point at which the addition of one more person causes aggregate well-being to decline.

Average well-being could decline very, very slowly as numbers increase, making the Classical Utilitarian optimum very large indeed. How large? Conceivably, the product (average well-being times population) could continue to grow even as average well-being declined towards zero—a level Dasgupta (2005a) calls "carrying capacity." What does it mean for well-being to equal zero? Positive well-being implies a good life. Negative well-being implies a life that is not good. But a life that is not good may still be worth living. After all, Dasgupta observes, the wretched cling tenaciously to life, demonstrating that their lives are worth living even if we believe the conditions of their existence are deplorable and should not be wished on anyone.

There is clearly something wrong with both of these approaches. Dasgupta's great insight was to see that both perspectives err by presuming that we are *starting from a clean slate* (the so-called Genesis Problem). That is, they both presume that everyone is a potential person, and that no one is an actual person. Dasgupta saw that we needed to distinguish between these types of person, and that existing people have rights that do not extend to potential people. Existing people, however, may wish for others to exist in the future. This is how potential people enter into the calculus.

History mátters. The current generation starts the process off. Its fertility choices affect the next generation; the next generation's choices affect the generation that follows; and so on indefinitely. In this intergenerational game, each generation chooses a fertility rate (and associated investment rate) that determines the optimal size of the next generation—where "optimal" is defined from the perspective of the generation that chooses how many children to have. In this formulation, optimal population isn't decided from behind a veil of ignorance. It is decided from the perspective of each generation. Appropriately enough, Dasgupta calls this *generation-relative utilitarianism*.

The earlier approaches looked at population as if it were to be chosen by a philosopher king. Dasgupta sees it as being determined by the people who are alive at any one time. These people also face ethical choices. For example, a couple contemplating having another child must think about the implications of

this decision for the children they already have, especially if having more children means offering less to the children they currently have. The suggestion in his theory is that ethical considerations *by the family* will limit population size.

Dasgupta's framework is richer than that of Average or Classical Utilitarianism for thinking about population. Analytically, though, it is more difficult to work with. One interesting feature of the theory is that the optimum sequence of population levels (and capital stocks) may not be unique. However, for an analytically tractable specification of the problem, Dasgupta has shown that, in general, generation-relative utilitarianism will commend a smaller population than Classical Utilitarianism. The two would make the same recommendation only if the weight attached to potential persons were equal to the weight attached to actual (living) persons—a condition Dasgupta argues can't be ethically justified.

1.5 HOUSEHOLDS

Resource allocation decisions within the household are also important. They determine who gets fed, who gets educated, who receives health care, how much a person works, the nature of that work, and so on. These choices in turn affect "outputs" like fertility, child survival, life expectancy, and literacy. As might be imagined, there is strong evidence that household allocation can be very unequal, with boys being favored over girls, older children over their younger siblings, men over women, and the strong over the weak. In addition, the extent of discrimination appears to vary with the overall prosperity of the household. In situations of famine in the Indian sub-continent, for example, there is evidence of men deserting their families—an act that benefits the man (given the extreme nature of the situation) at the expense of his wife and children (Dasgupta 1993: 305–42).

In this volume, Krishna Prasad Pant, Subhrendu Pattanayak, and Min Bikram Malla Thakuri explain that women and children bear the largest cost within the household of using traditional cookstoves. They gather the fuel; they breathe in smoke from the fire. Pant, Pattanayak, and Thakuri calculate that switching to improved stoves would yield a substantial net benefit to the household—and yet they find that very few families switch. This, these authors say, is a puzzle. Years ago, however, Dasgupta (1993: 335) remarked on the problem:

> Wherever household demands for goods ands services in the market reflect male concerns, the direction of technological change can be expected to follow suit.... Thus, cooking in South Asia is a central route to respiratory illnesses among women: women sit hunched over ovens fuelled by cowdung, or wood, or leaves. It is inconceivable that design improvements couldn't be realized at a

slight cost. But entrepreneurs have no incentive to bring about such technological innovations. Household demand for them would be low.

According to Dasgupta, a reason for the puzzle may be that households don't decide as a unit. Choices reflect bargaining within the household. This suggests that the way to address the problem is by redistributing bargaining power within the household—perhaps by making it possible for women to buy on credit, or by educating girls so as to improve their outside options as adults.

Joseph Stiglitz, in his commentary on the Pant, Pattanayak, and Thakuri chapter, suggests a different remedy. As Pant, Pattanayak, and Thakuri show, there are global benefits to switching to improved stoves. Stiglitz, however, thinks their calculations underestimate the true global costs by an order of magnitude. The problem would be solved, he thinks, if donor countries financed the switch.[2] Everyone would gain.

Household decision-making also features in the chapter by A. K. E. Haque, Z. H. Khan, M. Nepal, and P. Shyamsundar in this volume. They found that families in Bangladesh were more likely to avoid public wells painted red to indicate high arsenic levels (wells with safe water were painted green) when more male members were affected by arsenic poisoning than female members—even though women are responsible for water collection. Clearly, what is best for the man may not be best for the woman and vice versa. In this situation, however, we can't necessarily rely on donor aid to solve the problem. Arsenic in the water is a natural condition, a purely local phenomenon.

Moreover, the observed failure may have a multiplicity of causes. David Starrett, in his commentary on the Haque, Khan, Nepal, and Shyamsundar chapter, suggests two others—high discounting of future benefits from switching wells, and scepticism about benefits (as in, people need to see the benefits with their own eyes). Both problems will be difficult to overcome. Arsenic poisoning is a slow process.

1.6 COMMUNITIES

Why do people wish to have children? One motivation is the desire for their own creations, including their values, to live on, "projects that justify life rather than merely serve it." (Dasgupta 2010b: 271). This is also a perspective Dasgupta has taken to discounting, discussed later in this chapter.

Another reason is social or cultural, with couples, for example, taking cues from their community about the appropriate family size. When fertility is high,

[2] Of course, this suggestion only puts the spotlight on another incentive problem—collective action at the international level.

it is expected that every couple will have many children, and every couple is inclined to conform to those expectations. When fertility in the community is low, the target family size is lower, and the tendency to conform just as strong. These influences are hard to measure. For example, in a world in which community fertility is high, the returns to investing in female education will be low, and if young women are less educated, the opportunity cost to them and their husbands of having children will be low. This means that norms of offering little education to girls and high fertility may be mutually reinforcing. More generally it means that the outcomes we observe could be otherwise. Societies could just as easily sustain norms of educating girls and having small family sizes.

Yet another motivation for having children is the work that they can perform, and here again there can be a link to the community. As Dasgupta has repeatedly emphasized, the majority of the poor in the poorest countries rely on environmental resources for their livelihoods, with children contributing to the production possibilities of the family. "From about the age of six years, children in poor households in the poorest countries mind their siblings and domestic animals, fetch water, and collect fuel-wood, dung (in the Indian sub-continent), and fodder. Mostly, they do not go to school" (Dasgupta 2000: 634). When the resources available are owned by the community, and are poorly managed, more children may be needed as these resources are depleted, with the resulting increase in population putting yet more pressure on the resource. As Chopra et al. (1990), Ostrom (1990), and Baland and Platteau (1996) have all documented, communities are often successful in managing their shared resources. But the norms supporting effective management can turn sour; and, when they do, additional children create an externality for the community—an example of what Dasgupta (2000: 634) calls the "demographic free-rider problem."

The implication is unsettling. Even if couples have complete control over their fertility, and contemplate deeply the ethics of their decision to have children, they may end up having "too many" children due to circumstances outside their control. And the appropriate policy response may be complex: "the most potent avenue open for bringing down fertility rates in the semi-arid regions of sub-Saharan Africa and the Indian sub-continent involves the simultaneous deployment of a number of policies, not a single panacea, [with] the relative importance of the various prongs [depending] on the community in question" (Dasgupta 2000: 636).

This is a very different conclusion from the suggestion that, to lower fertility, we only need to "get the prices right" (a favorite among economists) or make birth control available. When you read Dasgupta's great work, *An Inquiry into Well-Being and Destitution*, you don't come away with a simple story line. Indeed, that is the point. Anyone who thinks that the secret to development is as simple as free markets, private property rights, or more overseas assistance hasn't understood the reasons for poverty.

His sensitivity to local conditions also sets him apart. His remarkable book (Dasgupta 1982), *The Control of Resources*, is sprinkled with evidence gleaned from field studies of the lives of the poor and their dependence on and exploitation of their local ecosystems. It is a tribute to his enthusiasm for such work that the chapters in Part III—the biggest part of this volume—are all based on empirical analyses of local conditions.

1.7 THE COMMONS

Failure to manage common property resources affects more than population size. In some rural areas, families obtain a third or more of their income from shared resources. For many who lack private assets, this common capital is of supreme importance.

Garrett Hardin's (1968) famous essay, "The Tragedy of the Commons," tells a parable of how self-interest causes herders to add cattle to the shared grazing lands without limit. The inevitable consequence, he argues, is ruin.

Hardin's description is vivid and unforgettable. But in his book, *The Control of Resources*, Dasgupta (1982) shows how easy it is for Hardin's powerful metaphor and compelling narrative to mislead. Using a simple model, he shows that, yes, herders have incentives to ignore the wider consequences of putting more cattle on the grazing lands. But he also shows that they don't have incentives to add to their herds without limit. There comes a point where even the private cost of adding an animal to the commons exceeds the private benefit. This needn't be the point of ruin.

It has also been observed that open access is not the same thing as common property, and that the alternatives to open access are not limited to government regulation and privatization. Communities can manage their locally shared resources, sometimes with remarkable success (Ostrom 1990; Baland and Platteau 1996).

But there has perhaps been a tendency to emphasize the advantages of communal management, while ignoring the disadvantages. Noticing that the theory of repeated games explains why communities may be able to manage their shared resources effectively, Dasgupta (2008) has observed that this same theory also explains that cooperation is hardly inevitable. Social norms can sustain a great variety of outcomes, including ones characterized by extreme inequality and inefficiency. Moreover, equilibria can be fragile. In particular, they can be knocked off their perches by external forces, such as improved opportunities for private investment over communally held property. The advantages of communal management over the alternatives can also change over time. As shown in the chapter by Jean-Marie Baland, the late Sanghamitra Das, and Dilip Mookherjee, community management of forests in South Asia

by the so-called Van Panchayats can be very effective. However, such organizations are hardly a cure-all. Worse, they can favor elites.

Baland, Das, and Mookherjee suspect that one reason for failure of local commons is the presence of non-local externalities. Many of the externalities in the countryside (landslides, siltation, and floods) are regional rather than local in nature. Indeed, by absorbing CO_2 in the process of photosynthesis, local forests have a global effect: on climate. Baland, Das, and Mookherjee find that pressures on the forests can be reduced by subsidizing heating gas in cylinders. They calculate that a subsidy of Rs. 200 per cylinder would reduce firewood consumption by 40 percent. In discussing their chapter, Geoffrey Heal argues that the value of forest conservation for carbon storage alone is substantial. Agreeing with Stiglitz, Heal supports a global subsidy.

1.8 INFORMATION PROBLEMS

Like community management, regulation of externalities can be imperfect. A central problem is information: the individuals and firms the regulator wishes to influence have private information. To regulate efficiently, the regulator needs that information. But the parties involved have incentives to keep their cards close to their chests. If pressed, they have incentives to lie. A central challenge is how to change these incentives—to get these parties to show their hands.

Common property management becomes more difficult as the number of users increases. Regulation can similarly become more difficult as the number of parties being regulated increases, so long as the marginal effect of the actions of each party depends on the actions of all the other parties—a common situation for environmental and natural resources. For example, the optimal pollution level will depend on abatement costs, which may be known to firms but not the regulator. Dasgupta, Hammond, and Maskin (1980) give conditions under which the optimum can be attained, despite the informational asymmetry, through a nonlinear tax scheme.

The analysis by Albert Honlonkou and Rashid Hassan in this volume is similarly concerned with incentives and information, but with a focus on forest management and imperfect information. Just as Dasgupta, Hammond, and Maskin (1980) rule out collusion among firms, so Honlonkou and Hassan assume that forest users act independently. However, Honlonkou and Hassan allow collusion between these users and their local supervisory agency. This opens the door to users paying the supervisor not to reveal evidence of illegal logging to the government—in a word, corruption. The government offers incentive contracts (akin to the tax schedules noted above) to both the

supervisor and the forest users. It wants the users to comply with the law. But to be sure that the users comply with the law, the government needs the supervisor to monitor the users, and to report truthfully whether the users are indeed complying with the law. Applying their analysis to the management of Benin's forest reserves, Honlonkou and Hassan argue that the contract currently offered by the government of Benin misjudges the incentives. No wonder there has been excessive deforestation in the country.

In commenting on this chapter, one of us (Eric Maskin) agrees with the authors that rewards are as important as punishments. But the comment also notes that, under the scheme proposed by Honlonkou and Hassan, the "supervisor" of forest activities would be rewarded by the government only for providing evidence of wrongdoing—meaning that he would have been paid nothing if he had succeeded in stopping all illegal activity! Just as important, this comment argues, the "agent" should also be rewarded for *obeying* the law.

1.9 THE TRANSNATIONAL COMMONS

In the transnational commons, there isn't a single government able to tax or regulate so as to correct an externality; there are, instead, a multiple of governments. In this volume, Sebastián Villasante, Rashid Sumaila, and Manel Antelo investigate the exploitation of a fishery shared by two countries that also straddles the high seas.

The fishery in question is for the Argentine shortfin squid, and the two countries are Argentina and the Falklands (Malvinas) Islands. (The United Kingdom controls the Falklands, although Argentina also claims sovereignty; in 1982 the two countries went to war over the islands.)

Villasante, Sumaila, and Antelo point to an opportunity for both sides to gain from cooperative management of the fishery. Compared to the non-cooperative outcome, effort should be lower and the stock of fish higher, resulting in larger joint profits. However, the authors also show that, compared to the non-cooperative outcome, this improved situation benefits the Falklands at the expense of Argentina. Clearly, side payments from the United Kingdom to Argentina could help. However, introducing them might raise significant political questions.

In his extensive and fascinating commentary on the Villasante, Sumaila, and Antelo chapter, Peter Hammond recasts their model in the framework of Dasgupta, Hammond, and Maskin. Hammond retains the dynamic dimension of the former chapter, but adds asymmetric information as regards harvesting costs as in the latter. This set up yields a dynamic version of the nonlinear tax (license fee) schedule.

1.10 NON-RENEWABLE RESOURCES

We usually think of the resources of the commons as being renewable, at least potentially so. Examples studied in this book include forests, aquifers, and fisheries. Of course, non-renewable resources can just as easily be held in common. Indeed, unitization of oil fields (whereby each owner receives a fixed share of the combined production rate) is an early example of redress for the tragedy of the commons. However, the aspect of non-renewable resources that disturbs us most is not their over-exploitation. It is their finite nature. We fear running out of them.

For some resources, exhaustion wouldn't be of great consequence. For the resources that are essential to production, however, it could be calamitous. Oil is the resource that comes quickest to mind.

In a seminal paper (Dasgupta and Heal 1974) and their now classic book (Dasgupta and Heal 1979), Dasgupta and Heal explore the nature of this problem. As might be expected, the optimal rate of depletion is a cousin of the optimum population problem. Deriving answers to both problems requires that consideration be given to investment. In the case of non-renewable resources, special attention also needs to be paid to the possibility that reproducible capital (machinery and so on) can substitute for the non-renewable resources, and that technologies can render non-renewable resources inessential (allowing a positive level of consumption forever).

While their model is quite general, its implications come into sharper view when Dasgupta and Heal make assumptions that focus attention on key parameters—the pure rate of time preference (or utility discount rate), the elasticity of the marginal utility of consumption (which captures the shape of the utility function, or social aversion to consumption inequality), and the elasticity of substitution between reproducible capital and the non-renewable resource (a feature of the production function). As might be expected, the results are of particular interest as the resource nears exhaustion. For example, Dasgupta and Heal (1974) show that it would never pay to exhaust a resource so long as its marginal product grows large as use of the resource declines, whether or not the resource is essential. Rather obviously, exhaustion is also undesirable if production is impossible without the resource.

This still leaves many possibilities for extraction and (after taking into account investment) consumption. An intuitively compelling benchmark is to maintain a constant consumption stream across the generations. This would be equitable, but it would also make the future captive to today's capital stock; there would be no development. As an alternative, we might allow early generations to lower their consumption so as to allow future generations to consume more. (In later work, Dasgupta has noted that this is what people have done for millennia: parents sacrifice for their children.)

Instead of forcing the model to give a particular solution (as in the constant consumption case), Dasgupta and Heal (1979) investigate a welfare optimum

from more primitive considerations. In a utilitarian framework, they show that, for positive time preference, the utilitarian optimal consumption path necessarily declines toward zero in the long run. This seems transparently unethical. Ruling out time discounting, they show that rising consumption is feasible (with the human-made capital stock substituting for resource extraction over time). More than that, they show that rising consumption can be *desirable*, with the optimal path for consumption depending on the social preference for a more egalitarian distribution of consumption. Intuitively, as this preference for equity increases, the consumption path becomes flatter. In the limit, if we insist on complete equality, we obtain the same result as before: a constant consumption stream. Backing off from this, saving by the current generation allows the future to consume even more—this being the central object of development.

One lesson of this analysis is that our judgment about ethical norms ought not to be contemplated solely in the abstract. As Dasgupta has repeatedly emphasized, the *implications* of an ethical stance should be considered before the stance is adopted. (We give a further example of the importance of this approach later in this chapter.)

In this volume, the chapter by Karnjana Sanglimsuwan, Erin Sills, Subhrendu Pattanayak, Shubhaya Saha, Ashok Singha, and Barendra Sahoo looks at another aspect of mining—its effects on the health of people working in and living near the mines. At first blush, it seems that mining would have to be harmful to health. After all, it is a dirty business. However, mining also brings employment; it raises incomes, and not only for workers and their families but also for the nearby community that serves them. To uncover the full effect of mine development on human health (let alone welfare) requires careful analysis. Using a survey of 600 households spread across twenty villages in Orissa, India, Sanglimsuwan, and coauthors are able to discern differential effects. Working in the mines increases the incidence of respiratory disease but reduces fever associated with malaria. By contrast, living near the mines increases the incidence of fever and waterborne disease. Unfortunately, the pathways that may be causing these effects are unclear. As Robert Solow remarks in his commentary, they bear closer examination. Solow also notes that the Orissa results may not generalize to other areas "because other causal chains and their interactions will be different." Dasgupta, as we have said before, has always put great stress on uncovering pathways and attuning policies to local conditions.

1.11 R&D, SCIENCE, AND TECHNOLOGICAL CHANGE

Dasgupta and Heal (1979) argue that the exhaustibility of a resource is of great concern only rarely because the resource is essential; usually, human-made

capital can be substituted for the resource to some degree. The more serious problem is that the resource endowment may be so small that substitution doesn't allow a reasonable standard of living to be maintained indefinitely. Technological change is then of great importance. It can ease the constraint of scarcity.

Technological change can take different forms. It can be disembodied, acting on the whole of the production function. It can be resource-augmenting, acting only on the resource input to production. It can also take the form of the invention of a "backstop technology," which substitutes perfectly for the resource at a high but constant marginal cost. If the date of the backstop's appearance is endogenous, there can be interesting strategic interactions between the parties that shape technological readiness and the parties that control the resource. It can be optimal for the resource importing country to bring forward the date at which the backstop becomes available, or to delay its introduction. Either way, the purpose is strategic: to influence pricing of the resource (Dasgupta, Gilbert, and Stiglitz 1983).

The example of a backstop technology that Dasgupta and Heal mention in their book is controlled nuclear fusion. That was back in 1979. Even now, fusion energy is a long way from being available. Indeed, a sustained chain reaction has yet to be achieved, despite tremendous investment. Before a fusion energy technology can be invented and developed, a lot more basic knowledge is needed. This is the realm of science (indeed, "big" science).

Most of us think of science as being abstract, basic, and speculative, resulting in knowledge whose main value is as an input in the production of yet more knowledge, including knowledge that may be used to develop new technologies or improvements in technologies. Dasgupta and Paul David (1987) propose a different classification. To them, the difference between science and technology is the "social ethos" of research. The goal of science is the creation of knowledge. The goal of technology is profit. In the scientific community, knowledge is to be disseminated for free. In the technology community, it is to be privatized for profit. The motivation of the scientist is recognition. The motivation of the technologist is profit. As between the two endeavors, Dasgupta and David believe that progress in science, which depends on public financing and self-regulation by the scientific community, is the more fragile.

But there are also problems with technological change. Though patents reward innovation, they also create monopolies. Dasgupta and Stiglitz (1980a and b) showed that market structure and innovation need to be considered jointly. Their research showed that there could be too much R&D, or too little; that there could be too much risk-taking, or too little; that there could be duplication of R&D effort; and that the pace of R&D could be excessive. Dasgupta and Maskin (1980) demonstrated that different firms' R&D efforts are likely to be too highly correlated. Essentially, these three papers showed that markets involving innovation are rife with failures. In this volume, Stiglitz

builds on this and related work to develop the theory of growth and development based on endogenous learning. His aim is to shift the discussion away from policies that move developing countries closer to their production possibilities frontier at any one time and towards policies that push the frontier out over time. The policies he advocates are industrial policies.

The intertwined problems of innovation and growth are particularly important as regards environmental resources. So long as externalities are unregulated and thus un-priced, not only will *current* allocations be inefficient, but the direction of technological change will also be systematically directed against the environment. This problem applies in spades for climate change, both because fundamental new technologies will be needed to reduce greenhouse gas emissions and because it is not within the power of any country to correct this externality on its own.

1.12 CLIMATE CHANGE

What to do about climate change? The optimization problem looks familiar. If we fixed the target steady-state concentration level (a stock), we could calculate the optimal path for emissions. This is the optimal depletion problem in reverse. Assuming that concern about climate change would make us want to leave some fossil fuels in the ground, the binding constraint would not be the resource reserve base but the target concentration level. Rather than optimize the exhaustion of a resource we should instead optimize the time-path for filling up of the atmospheric reservoir.

A more complete optimization analysis would involve choosing the steady-state concentration level. More particularly, it would involve solving *jointly* for the optimal extraction path and the optimal steady-state stock.

As might be expected, calculation of this optimum depends on the way in which the future is discounted. In a recent paper, Dasgupta (2012) provides a clear exposition of how previous researchers have approached this problem. He then shows that previous conceptualizations are wrong. More than that, he goes on to propose a completely novel conceptualization of the discounting problem.

Previous approaches all begin in the same way, by writing down an expression for human welfare. Intragenerational differences are averaged out. Population is also held to be constant over the generations. Each generation's utility is assumed to depend solely on its consumption level. Intergenerational well-being is assumed to depend on the time-discounted sum of these utilities.

Ramsey's (1928) enduring formulation of optimal growth, subsequently embraced by Cline (1992) and Stern (2007) for climate change, evaluates the ethics of choosing the time (or utility) discount rate directly. Should the utilities

of future generations be given less weight than those of the current generation? There seems to be no justification for this: zero seems to be the only ethically defensible value. But this presupposes that future generations will exist. Suppose there is a small probability that humans will become extinct. Then discounting would be permitted, but for factual rather than ethical reasons.

Koopmans (1960) took a different approach. He observed that, by investing in reproducible capital, saving by the current generation makes the future materially better off. Rather than choose the discount rate in an ethical vacuum chamber, he reasoned that consideration should be given for what this choice *implies*. In this framework, values for the discount rate and other parameters can be tried out. The emphasis here is on evaluating the consequences of choosing parameter inputs, not on the inputs themselves. Dasgupta clearly sides with Koopmans.

There is yet another approach. This is to choose a discount rate based not on ethics but on the values reflected in the choices people make in the marketplace. This is how Nordhaus (1994) has tackled the problem.

Cost-benefit analysis measures gains and losses in consumption, not utility, units. So it is consumption, not utility, that needs to be the basis for discounting for cost-benefit purposes.[3] The consumption rate of discount has two components, the time discount rate and a second term, equal to the growth rate in consumption times the elasticity of the marginal utility of consumption. The second term discounts the future if and only if future generations are better off than the present (consumption is higher), with the weight attached to this increase in consumption determined by social preferences for a more egalitarian distribution. If intertemporal equity was of no concern, this second term would be zero. If, to the contrary, there was a very strong preference for egalitarian outcomes, the second term would be very large.

One important implication of this is that, if climate change was expected to be calamitous, consumption would be forecast to decline in a business-as-usual world. As Dasgupta notes, if the elasticity of the marginal utility of consumption was positive and large enough, the discount rate on consumption would be *negative*. Obeying this formula, the current generation, quite reasonably, would be called upon to sacrifice more for future generations as compared with a situation in which climate change was not calamitous (Dasgupta, Mäler, and Barrett 1999).

Of course, if the current generation made this sacrifice, business as usual would not be realized. We see, then, that we should think of future consumption

[3] This is also the approach taken in Dasgupta, Marglin, and Sen (1972) for project evaluation. Little and Mirrlees (1969) use investment as the numeraire. It shouldn't matter for decision-making which approach is used, so long as each is used correctly and consistently. If consumption is the numeraire, then costs and benefits must be discounted at the consumption rate of discount. If investment is the numeraire, costs and benefits must be discounted at the investment rate of discount.

not as a forecast but as something to be chosen. This is the problem of optimal growth with climate change.

As noted before, Nordhaus takes his values for the consumption discount rate from market observations—the rate of return on capital. This is a valid procedure for an optimal economy, but the real world is far from optimal, not least because it has failed to limit climate change! At the same time, Stern ignores the opportunity costs of investing in CO_2 abatement—the returns that could be used by investing that money elsewhere in the economy. As Dasgupta explains, the way to address opportunity cost is to revalue the price of investment for abatement, not to fiddle with the discount rate. So Nordhaus is wrong to force discount rates to equal their market values, while Stern is wrong to price abatement as if there were no opportunity cost.

Dasgupta clarifies how we ought to evaluate climate policy. But he then takes a bold and original move. He suggests that we need to rethink the welfare function. By assumption, the standard formulation discounts all utilities the same, the utilities of a single individual over his or her lifetime, and the lifetime welfare of future people. He notices, however, that intertemporal choices have both private and public consequences. As with his approach to population (recall the way he distinguishes actual from potential people), he respects the decisions people make about distributing lifetime consumption over their own lives, while at the same time recognizing that these same people may wish to discount the lifetime welfare of future people at a different (lower) rate. By this formulation if people live very, very short lives, only the discount rate on lifetime welfare matters, and we are back to the standard interpretation. If, however, people live forever, then only private rates of discount matter. For the average human lifespan, the discount rate suggested by this formulation lies between these extremes. By extension (and Dasgupta demonstrates this), it lies between the discount factors employed by Nordhaus and Cline/Stern.

Overall, then, Dasgupta's new formulation embraces the ethical challenge of climate change, but not from the lofty perspective of the philosopher king. It respects market values as these determine opportunity costs, without letting these values be the sole determinant of one of the biggest ethical problems in human history. As with his work on population, his perspective is decidedly democratic. It also has empirical content, being sensitive to the choices people make and would like to see being made.

1.13 SUSTAINABLE DEVELOPMENT

The concept of sustainable development, which burst onto the scene in the 1980s, shows no sign of disappearing. One reason for its appeal is that the alternative, "unsustainable development," is repugnant to anyone who thinks the continued

existence of *Homo sapiens* is a realistic prospect. Another reason is that the concept can embrace a variety of "worldviews." But this, of course, is also the problem with the concept. If it can mean almost anything, it will mean almost nothing. This is why so much effort has been devoted to understanding what it ought to mean.

Dasgupta has done more than anyone else to define the term so as to make it useful for making policy and investment decisions. He saw at once not only that the concept related to his earlier research on exhaustible resources and population (as noted previously), but that it also related to his earliest work on cost-benefit analysis and project evaluation (Dasgupta, Marglin, and Sen 1972). How to know if economic development is sustainable? He showed, first, that the relevant measure is intergenerational well-being. That is, development is sustainable if the integral of discounted social well-being into the distant future is non-decreasing (Dasgupta 2001: 140). He also showed that this condition is equivalent to the requirement that an economy's wealth be non-decreasing.

A project or policy is a perturbation to an economy. Project evaluation is used to answer the question of whether a project or policy should go ahead. It should go ahead if its net present value is positive. Of course, net present value is a measure of wealth, a stock, rather than income, a flow.

A state's wealth comprises its institutions and its capital assets, to include plant and machinery, obviously, but also human capital, knowledge, and environmental and natural resources. An aggregate measure can be calculated by attaching weights to the different assets. The weights are shadow or accounting prices, calculated as the change in social well-being that would result if the amount of an asset were to increase a little bit (Dasgupta and Mäler 2000). Of course, it is the change in wealth that is of primary interest—net investment which, given the above framework, can also be described as genuine investment.

Some matters are rather easily described analytically but are hard to measure. Sustainable development is difficult on both fronts. Institutions cannot be equated to capital; and so cannot be added to the capital base. Population change also creates conceptual challenges. Arrow, Dasgupta, and Mäler (2003) argue that population should be treated as a capital stock. But that means that population change determines well-being, even as sustainable development is being evaluated for the benefit of the population that is changing. Dasgupta (2001) has shown that there are circumstances in which it is reasonable to consider genuine investment per capita as an indicator of sustainable development, but these conditions are rather special.[4] Another problem is how to account for climate change. When a country adds greenhouse gases to the

[4] Wealth per capita is the correct indicator of sustainability if intergenerational well-being is the discounted value of well-being at each time divided by the discounted value of population size at this same time; see Dasgupta (2001: 258–9). You will recognize this as being analogous to the notion of average utilitarianism discussed previously.

atmosphere, should the effect on that country only be reflected in the shadow price, or should the effect on every country be calculated?

Alternative measures that have found popularity are more easily defined and calculated. Ask anyone for a measure of progress, and they are likely to mention GDP per capita. Others may say (total factor) productivity. Still others will cite the Human Development Index. Dasgupta has shown that, if we care about sustainable development, then none of these measures serves as a useful indicator. Based on some crude calculations (drawing from the work by Hamilton and Clemens 1999) of genuine investment, he shows that such indicators can even be of the wrong sign (Dasgupta 2007b). While estimation of genuine savings is still at an early stage, Dasgupta has shown that ignoring the environment and natural resources in national accounting gives a grossly misleading impression. A country can appear to be progressing, and yet be eating into its capital base. What we see as success today may only be a down payment on failure tomorrow.

The greatest estimation problem lies with those shadow/accounting prices that are unobservable. A number of techniques have been developed for inferring such values. The greatest difficulty lies with those values for which even indirect estimation is impossible. In these cases, the only option is to ask people hypothetical questions about their willingness to pay.

In developed countries, application of this technique—called "contingent valuation"—is a virtual industry. There are, however, very few estimates for poor countries (Viscusi and Aldy 2003). In this volume, Rosalina Palanca-Tan makes a useful contribution to this small literature, estimating the value of statistical life of children in metropolitan Manila—a value that would be of great interest for carrying out cost-benefit studies of policies and investments that affect child mortality. Her approach is to estimate willingness to pay for a dengue vaccine that would both save lives and also reduce morbidity. Her approach yields a value of statistical life around $750,000.

In his commentary on Palanca-Tan's chapter, Shantayanan Devarajan supports the approach, but warns that the utility of having such values is limited in a very imperfect world. For example, using such values to support investment in hospitals would not improve the lives of the poor, if the investment calculus neglected the problem of doctor absenteeism. Put differently, for values like the one estimated by Palanca-Tan to be really useful, related market and institutional failures must be corrected.

1.14 INDIA AND THE WORLD

Partha Dasgupta was born in Dhaka, which at the time was part of India, and received his first degree from the University of Delhi before moving to

Cambridge, England, where he met his wife, Carol, and where they both made their home and raised their family. It is hard to think that his work wasn't shaped by both places. How could it not be? Dasgupta's father, the distinguished Indian economist A. K. Dasgupta, was his greatest influence. In England, his PhD supervisor, James Mirrlees, made an indelible impression.

We began this chapter by asking where a researcher gets his ideas. When asked this question in an interview given in 2010, Dasgupta responded, "By observation, I guess." He went on to give an example:

> On one occasion in the early '80s, when passing through Calcutta on my way to visit my parents in Santiniketan, I noticed that the baby of a mother beggar on the sidewalk was being molested by flies. I thought, "That's odd. Why isn't the baby swatting the flies?" Then it dawned on me that the baby was conserving energy. That eventually triggered my joint work with Debraj Ray on malnutrition and the capacity to work.[5]

We are only speculating, but perhaps living in England gave Dasgupta the outsider's sharpened observational powers. Perhaps his childhood memories of India, rekindled by frequent visits, gave him the empathic powers needed to see things from the child's own perspective.

In the penultimate chapter of this book, Amita Shah explains the many interconnections between poverty and natural resources in India. Dasgupta has always stressed the importance of uncovering the pathways that establish cause and effect, and Shah gives a good example of this in irrigation. She notes that people with access to irrigated water fare better, but that, because access to ground water is unregulated poverty may worsen as the ground water is depleted. This is a perfect illustration of how misleading current measures of output such as GDP can be as indicators of intergenerational well-being. As Kanchan Chopra notes in her commentary on Shah's chapter, it is also a prime example of how important institutions are for addressing the connected issues of poverty reduction and natural resource use. The question, she asks, is whether politics in India is capable of correcting the institutional failures that portend a bleak future.

There is reason to be encouraged. Dasgupta was recently invited by the Government of India to chair an expert group on Greening India's National Accounts. In a paper prepared for this group, Dasgupta (2011c) explains how to conceptualize and go about constructing a comprehensive system of national accounts. If India were to adopt such a system, and evaluate its projects, policies, and overall progress in the light of it, intergenerational well-being in India would improve. If other countries adopted the same system, this positive effect would be reinforced. Universal adoption of a system of accounts that reflected the opportunities for, and limits to, substitution of human-made capital for

[5] Bowmaker (2012: 172–3).

natural capital wouldn't by itself prevent development from being unsustainable, but it would make such a bleak future much less likely.

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