NATURAL RESOURCE AVAILABILITY

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Contents

Summary

The importance of natural resources and concern over their availability have been central to economics since its inception, albeit with periods of apparent neglect and even disdain. Anxiety over availability has surfaced again in recent times, encouraged by the environmentalist movement, but most mainstream economists have remained optimistic, trusting in the powers of technology and substitution, supported by market forces, to avert any predicted shortages. On the other side of the debate, actual and irreversible damage to ecosystems is pointed out and projected to worsen, propelled by population growth and technical constraints. Whether natural resources are getting scarcer or not, and whether scarcity can be abated by restraint or by other means, are issues being discussed, along with new concepts including carrying capacity, critical ecological limits, and sustainability. These concepts, though illuminating, have not been operationally defined with any precision. Within the sustainability movement there are also differences. Strong sustainablists urge the preservation of the stocks of natural capital undiminished, claiming they have no practical substitutes, while weak sustainablists acknowledge some substitutability between natural and produced capital, insisting, however, that the total of all forms of capital should be kept intact. Discussion

of biological diversity and ecosystem resilience has more recently raised issues of ethics and aesthetics, besides the older danger of economic loss, with arguments in favor of precautionary measures in the face of uncertainty. Solid contributions from the physical and biological scientists remain operationally lacking, and better interdisciplinary cooperation is obviously needed. But the responsibility of economists is more tangible and urgent, and their specific tasks have been clarified.

Several areas of public policy need to be initiated or strengthened, including sustained efforts at conservation, and seeking and developing substitutes. Distribution of income and wealth, both intra- and inter-nationally, is of great importance and should be an integral part of targeting sustainability. Rich and poor nations alike should be allowed to pursue higher levels of material comfort, provided growth is genuine, emanating from value added and not from natural asset destruction: hence the crucial role that can be played by green accounting, provided it is properly done. The movement towards the de-materialization of production, which has already begun in Western Europe and North America, has a useful role to play. Availability would be secured if, to the extent possible, lifestyles everywhere were patterned on modes that are less wasteful of natural resources.

1. Introduction

Whether natural resources have become or are becoming more scarce than previously and whether this is a topic of critical importance is not an issue that can be easily settled. Strong arguments are advanced on both sides of a continuing debate. There are optimists and pessimists over natural resource availability, but most environmentalists have little doubt about the present danger signs and likely further deterioration. To them, these signs should be taken seriously and their causes understood and averted. The required measures are often costly and unpopular, and thus may be a cause for denial of existing problems. Danger of further increases in world population is particularly feared. Even with declining rates of growth, the yearly additions to population are substantial, given the large size of the base. Larger populations and higher per capita consumption combine to put increasing pressure on natural resources. Aspirations for higher consumption are ubiquitous, even in the more affluent parts of the world where consumption may in some respects appear excessive and wasteful. Many people in the developing world wish to catch up eventually with the standards of living enjoyed in the industrialized countries, which global communications now bring vividly to their notice. If the masses of India and China were to attain the levels of high consumption of North America and Western Europe, there is little doubt, other things being equal, that the pressure on natural resources and their ecological infrastructure would be unbearable. Today, even in the richer parts of the world, pollution of the atmosphere and waterways, acid rain, waste landfills, noise, urban congestion and numerous associated problems exist and even worsen, despite serious attempts at abating them. People often seem resigned and able to put up stoically with higher levels of discomfort. Optimists argue that the market will take care of these problems, if not immediately then eventually. They stress the positive association found between higher incomes and attending to pollution, and believe that substitutes for natural resources are bound to be found, as has happened in the past in case of some individual materials. For securing raw materials and energy, the richer nations, with their superior purchasing

power, have had easy access through trade and other arrangements to natural sources from the developing world. Even their harmful wastes have occasionally been dumped at a price in the poorer countries. Their demand for raw materials is not much discouraged owing to the relatively low prices prevailing. Such low prices are the outcome of various factors, and on the whole do not cover the full ecological costs of their production, renewal or assimilation of their wastes. Resort to fertilizers and pesticides in pursuit of higher agricultural production is causing multiple harms that are not reflected in product prices. Nor is the user cost of exhaustible resources included fully in the price of products whose sources cannot be renewed. Trust in the ability of the market to bring satisfactory solutions as and when required is strong in some influential circles, and is often backed by politically motivated forces. But can the market on its own be expected to solve the problem of species that are approaching extinction, save ecological systems that are irreversibly being undermined, or arrest the depletion of the ozone layer? Consciousness of the crucial importance of energy to established living styles, and anxiety over its sources, have been around for at least three decades, but no breakthrough has yet materialized for alternatives to fossil fuels although some progress has doubtless been made. Clearly serious and sustained public intervention is called for, since the market needs strong help and cannot bring solutions to these complex and long-term problems on its own.

2. Availability and Scarcity

The phrase "natural resource *availability*" conjures up at once its converse, which is "natural resource *scarcity*". Since scarcity is essentially the subject matter of economics, this entry is fundamentally about the *economics* of natural resources, and whether or not resources have become or are becoming scarcer than previously, and whether such scarcity would prove to be an impediment to economic growth, an objective that is taken for granted by most economists. Among the issues discussed, therefore, will be the possible effect of reduced natural resource availability on future production and consumption, on human welfare generally, and to some extent on the complex relationship between natural resources and their ecological infrastructure which is increasingly being recognized, not just as necessary for sustaining economic activity, but also for supporting life itself. Apart from anything else, natural resources cannot be dissociated from their roots in ecological systems.

3. Concepts and Classifications

There is a vast variety of natural resources, a fact that impedes their categorical description, and renders generalized analysis and policy pertaining to them difficult. Several classifications have therefore been attempted, some of which are maintained in this entry. A common dichotomy is that made between renewable and non-renewable (or exhaustible) resources, but it will be seen that all natural resources are in fact exhaustible. Another distinction is made between "sink" resources and "source" ones, the former referring specifically to the class of natural resources whose function is absorbing and assimilating wastes, and the latter to the source of raw materials and energy. Some resources, such as forests, have a dual quality, both as a source of timber and other products, and a sink for carbon dioxide. Source resources used in production and consumption inevitably produce wastes; so both functions are intimately related.

There is also the distinction usually made between appropriable and inappropriable resources, and shades of private and common ownership in-between. Some resources are altogether inappropriable or just not appropriated, such as the atmosphere, the high seas, or the ozone layer; others are held and exploited in common; and yet others are individually worked with established owner rights, and this form of ownership is held by some to be a key to sustainable exploitation. There is a class of resources often referred to as amenities, which provide direct enjoyment, and these tend, with public encouragement, to fall outside private ownership and the mechanism of the market. Other aspects of natural resources get stressed by ecologists, such as species extinction, loss of biodiversity, and man's predatory appropriation of global ecosystems, which is said to encroach on the survival claims of other forms of life. Natural resources, it should be realized, are complex and diverse, projecting a multitude of aspects that are variably stressed by different analysts. It is their close association with the economic system, however, that makes them interesting to economists and worthy of their serious attention.

All resources are in essence non-renewable or "destructible". Fish, forests and the like, if exploited with a view to sustainability, can renew or can be helped to renew themselves, provided that the periodic intake from them is kept within their re-generation capacity. But if they are "mined" they can clearly be exhausted. When over-exploitation reaches a certain level and culling or destruction is allowed to exceed renewal by a critical margin, resources can tend irreversibly to extinction – a fate that has afflicted a number of species. On the other hand, the exhaustion of non-renewable resources can be reduced somewhat by recycling, and their effective life may be extended by efficient use and the development of substitutes. But recycling is out of the question in some cases. Certain resources, such as fuels, once combusted, cannot be redeemed – an atrophy indicated by the second law of thermodynamics.

Opinions differ as to which of the two categories of natural resources, the renewable or the exhaustible ones, will prove to be the limiting constraint on economic growth. Some writers emphasize the erosion of topsoil, declining water tables and deforestation as the more limiting of the two as these are bound to affect food production and the absorption of carbon dioxide. Thus the belief, once held, that biomass could provide a useful substitute for fossil fuels now increasingly appears dubious. Both renewable and nonrenewable resources are probably on the same level in respect to scarcity and its possible intensification.

The distinction between resources as "source" and "sink" has proved to be a useful one for many purposes and has had a great impact on the analysis of "sustainability". Again, whether the threat to sustainability will come first from the inability of nature to absorb and assimilate further wastes, or from our running out of source resources whether exhaustible or renewable, has been a matter of debate with special attention paid to reversibility. There are signs that pollution can be abated and reversed, while source resources are in many cases more difficult to restore. As previously stated, both sink and source are connected in that the source inputs of production pass through the productive processes as "throughput", and inevitably translate in part into harmful wastes. The notion of throughput has inspired the recent drive towards "de-materialization", or reducing the ratio between natural resource inputs and the final outputs.

4. Resources and Classical Economics

Economists are often blamed for their apparent myopia over natural resource scarcity and for overlooking the ecological aspects of economics generally. While this may be true to a certain extent in more recent times, it has not always be so, and the history of economics shows how wrong this view is. Natural resource scarcity attracted economists' attention almost from the birth of their discipline, but there have certainly been periods when their attention to resources wavered. Over the last two centuries interest in the adequacy of natural resources for sustaining the economic system rose and fell in waves, to emerge in our own time as of great importance. From the beginning, the British classical economists emphasized land as an original and crucial factor of production, taking land to include natural resources. They had borrowed freely from the French school of the Physiocrats that flourished in the second half of the eighteenth century. The Physiocrats held that "land", which to them largely signified agriculture, was the origin of all wealth, and believed that it was only nature, not man, that was capable of creation. Their views had religious undertones, which were discarded by the classical economists. Concern for natural resource availability is to be found in Adam Smith's *Wealth of Nations* (1776) -- a concern that became central to Malthus's *Essay on Population* (1798). Malthus presented as a problem of great moment the balance between people and the ability of agriculture to provide the means of their sustenance. Such a balance was necessary for keeping the workers alive, providing the essential factor of production, named labor, which complemented land. Later, in his *Principles of Political Economy and Taxation* (1817), Ricardo was to analyze natural resource scarcity in terms of changes in quality. As demand increased for land and the products of mines and quarries, inferior quality sources had to be sought. Quality deterioration raised the costs of extraction and reduced rent as the margin of cultivation moved progressively into less productive areas.

Half a century later Jevons, whose name is associated with the marginalist revolution in economics, and who is frequently considered as a neoclassical economist, gave much attention to what he perceived as the growing scarcity of coal, not so much in quantity as in quality. Jevons focused on coal because to him it was a basic ingredient of British industry and thus underlay British international supremacy. In *The Coal Question* (1865) he reiterated Malthus's fundamental concern over the impending inadequacy of supplies to meet demand. Jevons's pessimism, however, had a short life. This is because agricultural produce and minerals became quite abundant in the last decades of the nineteenth century, with the settlement of new territories in the Americas and Oceania. Abundance was also aided by revolutionary advancements in transport and in manufacturing processes. Doubts over the scarcity of natural resources subsided, and economists began to look elsewhere for other problems of concern.

For the first half of the twentieth century optimism seemed to reign, rooted in a newly restored confidence in "human ingenuity" as an antidote to the classical economists' view of the "niggardliness of nature", which had branded political economy as the "dismal science". The "law of diminishing returns" appeared not to be as universally dominant as it had been previously thought. Even the population threat seemed to have been abated, if not completely vanquished, as demographic growth slowed down in the older countries, thanks to out-migration, and the impact on family size of urbanization

and improvements in medicine and technology. Though the population danger lingered on in the poorer countries, many thought it would be similarly conquered, with higher incomes, education, and family planning, which would bring about demographic stability.

5. The Neoclassical Contribution

While concern over resource scarcity never quite died down, the topic continued to engage the attention of the new, and increasingly influential, school of neoclassical economics, which emerged towards the end of the nineteenth century. Today, neoclassical economics is frequently misunderstood, and even maligned by non-economists, partly on the grounds of its neglect of natural resources. Admittedly, resource scarcity has not always occupied center stage in its adherents' writings, but it has received serious and sometimes profound attention. Contributions in this regard have tended to be more "positive" and analytical than "normative" or advocacy-orientated. Outside the environmentalist literature, warnings of imminent difficulties were kept in the background, while objective analysis was promoted generally in small doses without being quite central. Important in this regard is the work of three economists of standing. The first of these was Alfred Marshall who is widely recognized as the father of neoclassical economics and whose *Principles of Economics* went into eight editions between 1890 and 1920. Marshall revived the old notion that the factor of production named "land" did cover natural resources, including in his words, "rivers and the sea". His concern for nature was behind his drive to develop the study of economics along lines borrowed from biology, resenting others' attempts to imbue it with concepts from mechanics and physics. He paid special attention to the destructibility of natural resources, as in mining, insisting that the surplus derived from their exploitation was not all in the form of Ricardian rent, originating from the "indestructible powers of the soil". The process of mining itself depleted the "store of nature". Besides rent proper, the surplus realized in mining contained a "royalty" that signified resource depletion. To Marshall, royalty represented nothing less than a portion of the mine itself, not a surplus. This royalty, later recognized as a "user cost", or "resource rent", is in essence a temporal opportunity cost arising from the fact that if a unit of a mineral is taken out of the ground today, it will not be available for extraction tomorrow.

One of Marshall's penetrating ideas in this regard, which, however, tended to be overlooked, was his insistence that, although Ricardian rent did not enter into the marginal cost of the extracted mineral, "the minimum royalty did enter directly into the expenses incurred on behalf of every part of the produce, whether marginal or not". This novel thought, that the marginal revenue in mineral extraction could be above the marginal cost of working the mine, was a seed that later germinated under the careful husbandry of Hotelling. In time the concept of the user cost came to be accepted, and has been found to apply also to renewable resources, such as forests and fish, when these are being "mined".

Another neoclassical economist with an eye on natural resources, more as a sink rather than a source, was Pigou who initiated the sub discipline of "welfare economics". Pigou expressed his concern largely around the concept of "economic welfare", which he

defined as that part of human welfare that could be brought into a relationship with the measuring rod of money. His famous book began as *Wealth and Welfare* in 1912, and was subsequently expanded into *The Economics of Welfare,* four editions of which came out between 1920 and 1932. There, Pigou expounded his notion of *externalities*, which signified deviations between private and public costs and benefits. Pollution created by industrialists inflicted damage on their neighbors who bore its cost whereas the benefits accrued to the polluters. This notion was later to prove invaluable for anti-pollution policy, and instrumental in the drive to identify the sources of waste and eventually regulate, penalize and tax the offenders. Thus was born the "polluter-must-pay" principle, which seems now to meet with general acceptability. The divergence between private and public interests has come lately to the fore over nuclear power generation, which is held by some to be both clean and cheap. The scarcity of uranium apart, if the costs of countering the radioactivity of wastes were properly internalized, nuclear power generation would be prohibitively costly. The notion of externality was later to be found relevant also to "source" resources, where the market still overlooks soil erosion or a declining water table in appreciating the full costs of agricultural products.

Hotelling's was a third influential voice raised from within the neoclassical economic tradition but with a centrality for natural resources that was quite revolutionary. In his justly famous article, "The Economics of Exhaustible Resources", in the *Journal of Political Economy* of 1931, he confronted head on the issue of natural resource scarcity. This seminal work developed out of his concern over the world's disappearing supplies of minerals, forests and other exhaustible assets, a concern which indicated to him a need for regulating their exploitation. He asserted that natural resource products were too cheap and were being used selfishly and wastefully. Hotelling applied the calculus of variations, a mathematical tool unfamiliar at the time to most economists, to the problem of optimal allocation through time of a given stock of a natural resource. In the manner of neoclassical economics he relied on some drastic simplifying assumptions to get to the heart of the problem. "Hotelling's rent", an articulated version of Marshall's royalty, was a measure of scarcity that, along Marshallian lines, should be part of the price, lying between the marginal cost of extraction and the market price. Under his assumptions, as the stock diminished, scarcity rent grew, pushing up the price. The connection between scarcity and price was indirect. It was the user cost contained within the price that would rise, and not necessarily the price. This view was in harmony with asset management, with natural resource stocks viewed as assets to be managed according to the same profit maximization principles. Since the growing scarcity of a natural resource raised the scarcity rent exponentially at the current rate of interest, an individual owner would regulate the rate of extraction in such a way as to leave him indifferent between keeping the mineral in the ground to appreciate or drawing it out and reinvesting the proceeds at the prevailing rate of interest. Hotelling's work covered many other related issues of importance for natural resource management. But notwithstanding its profundity, it remained largely neglected until it was revived and its relevance rediscovered by Solow and other mainstream economists in the1970s in the wake of the energy crisis. Among analytical economists, the erroneous emphasis popularly placed on the power of exporter cartels to raise oil prices gave way gradually to the appreciation that petroleum was an exhaustible resource whose price should be expected to rise *à la* Hotelling. One reason for neglecting Hotelling's work in the

interval was the apparent lack of empirical evidence to support his thesis of growing natural resource scarcity.

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Biographical Sketch

Salah El Serafy is an international economic consultant who holds two first degrees, one in business from Alexandria University, Egypt, and the other in economics from the University of London, and a doctorate in economics from the University of Oxford. He served as professor of economics at Alexandria University, and a Fulbright post-doctoral Research Fellow in Economics at Harvard University. Subsequently, as Project Director of the Economist Intelligence Unit (EIU), London, he conducted economic research for eight years on a wide front of issues involving field studies in developed and developing countries. He later spent twenty years at the World Bank, Washington DC, as a Senior Economist, Adviser and Senior Adviser, working largely in central departments on macro-economic policy issues with numerous field assignments.

Since retiring from the World Bank in 1992, Salah El Serafy has been a consultant to several national and international entities on environmental economic matters, serving on the Editorial Boards of *Ecological Economics* and *Environmental Taxation and Accounting.* He was Leader of the World Bank's team for evaluating the Global Environment Facility (Pilot Phase), whose joint report with UNEP and UNDP was published in 1994. His publications include the "Proper Calculation of Income from Depletable Natural Resources", which was published by the World Bank jointly with UNEP in 1989 as a chapter in *Environmental Accounting for Sustainable Development*. This re-introduced the "El Serafy Method" (first published in 1981) found useful as an instrument for sustainability.