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Economics and Management of Environment and Resources

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1. Setting the Scene

The world-wide decay in environmental quality conditions and the gradual depletion of natural resources, sometimes referred to as the 'new scarcity', has been a dominant theme for research and public policy during the latter part of the twentieth century. The global interest in environmental matters is partly caused by the increased pressures that a mounting population and increased production exert on the earth's natural resource base. In addition, as personal incomes rise and leisure time becomes more freely available in the developed world, concern with more immediate human needs has been accompanied by an interest in preservation and conservation for future generations and for other regions of our world. We observe an increasing interest in 'quality' – next to 'quantity' – as an important constituent of individual and collective welfare.

It seems likely that the issue of environmental degradation will stay with us until far in the next millennium. Already Plato in his Kritias was complaining about human activity which had turned the landscape of Attica into a skeleton and a wasteland. We also know about environmental regulations in medieval European cities which aimed to control the use of coal burning or the noise annoyance caused by horse drawn carriages. And the early stage of the Industrial Revolution demonstrated an abundance of urban environmental quality degradation. But in our era the size and the intensity of resource use and of related environmental decay have taken such massive forms that the stability and sustainability of many ecosystems - both locally and globally - is threatened. This has stimulated the launching of the concept of sustainable development in research and policy making at the end of the 1980s as well as the international research on biodiversity loss and climate change risks during the 1990s.

Much of the early interest of the last century centred on public health in dense agglomerations. As socio-medical knowledge on how diseases spread developed, urban authorities in particular sought to improve the local environment by such measures as sewage control and clean water supply to reduce the diffusion of germs and infection. This trend, much later, lead to policies embodied in various initiatives of clear air legislation to reduce local atmospheric pollution that causes smog and other harmful effects. Wealthy societies, and the better off within poorer societies, with the time and resources to expand, became concerned with the built environment and with shaping nature in ways that they found aesthetically pleasing. Over the centuries this has led to specific patterns of landscapes in the countryside and the provision of parks and gardens in urban areas. This has created a general concern on quality of life, in addition its dependence on resources and environment.

The resource and environment base of our earth is a complex system that comprises an enormous diversity of forms composed of biotic and non-biotic components. Essentially, the resource and environment base is made up of three main interrelated classes:

- biotic resources emerging from soil or water (such as vegetation and animal populations);
- a-biotic resources with productive or consumptive nature (such as minerals and energy);
- environmental components needed for our wellbeing (such as clean water or fresh air).

Traditionally, resources can be subdivided into renewables (which may be replenished with or without human intervention) and non-renewables (which cannot be reproduced within a meaningful time horizon). Both types of resources can be depleted.

The main problem in environment and resource management is the interwoven nature of the 'new scarcity' question. Resource use leads to pollution, and abatement of pollution requires additional resource use. Clearly, technological innovation (e.g., recycling) may help to alleviate some of these problems, but with a rising population and rapidly rising consumption and mobility levels it will be extremely difficult to achieve a sustainable development over a time scale involving may human generations. Furthermore, resource and environment issues may manifest themselves at local or regional scales, but they are part of a globally interwoven ecosystem. Consequently, the 'new scarcity' has clear spatial and temporal horizons which extend far beyond the current level of thinking and acting.

Against this background, the concept of sustainable development has become 'en vogue'. Although this notion has already a longer period of existence, it became a fashionable topic after the publication of 'Our Common Future' by the World Commission on Environment and Development (WCED) (also known as the 'Brundtland Commission'). The Commission called attention for the need to consider our planet as an integrated social, economic, ecological and political system which needs collective initiatives and actions in order to ensure continuity under changing conditions. The report suggested that economic growth and environmental protection can go together, which was subsequently tested by Duchin and Lange (1994) using a multisector-multiregion model for the world. Their conclusion was negative. In the next section we will give a concise historical record on the evolution of environmental thinking, to be followed in subsequent sections by a discussion of major themes in resource and environment management.

2. Back to the Roots

The scientific analysis of the physical conditions of our earth has already a history of many centuries, as is witnessed by the body of knowledge collected in such disciplines as biology, physical geography, archaeology and chemistry. It is surprising that the social sciences were latecomers in studying issues of environmental quality and nature. Of course, there are early examples of social science research on environmental and resource issues, for instance, by nineteenth century scientists like Malthus and Marx. But it lasted until the 1960s and 1970s before the urgency of environmental degradation and resource depletion had become so widely recognized that various social science disciplines started to develop a pathway for environmental research. This does not mean that in some disciplines never any attention had been given to resource and environment issues. On the contrary, in particular in economics we observe a long-standing interest in resource scarcity, in relation to agricultural land use and mineral use. The Physiocrat thinking in economics even advocated that nature - in particular, land and water - were the real sources of economic wealth. But this early interest in resource use was mainly instigated by the (positive) productive contribution of physical resources for economic efficiency. Only a few economists in the first part of the twentieth century-.. recognized the 'unpriced scarcity' nature of the environment and of many resources (notably

Marshall and Pigou). They introduced the concept of 'externalities', which meant that the social value of various goods and services, including nature and the environment, is not or not insufficiently reflected in market prices, so that a socially undesirable use of these goods and services will result. This may be the result of myopic behaviour of selfish people or of the public good nature of various resources that are not controlled by property rights or proper regulations.

The real interest in environmental issues started essentially in the 1970s when the growing recognition of a worldwide environmental decay and of severe resource depletion (in combination with a population explosion) received an unexpected but welcome support in the oil crisis. This sudden event was complemented by the First Report to the Club of Rome ("The limits to growth"), which was based on a scenario analysis with a systems dynamics model of the World. Although the scientific contents of the latter study left much to be desired – as a result of conservative information on resource availability and insufficient incorporation of negative behavioural and technological feedback mechanisms – it created a shock effect among social scientists. This gave rise to an intensive debate between growth optimists and pessimists (Daly and Townsend 1993).

This also marked the beginning of the social science interest in environmental sciences. Economists constructed abstract models of economic growth and resource use (Dasgupta and Heal 1979) and developed a theory of environmental policy for correcting environmental externalities (Baumol and Oates 1988). Economists and psychologists began to investigate how people value environmental change, environmental policy and ecosystem management, using stated preference and revealed preference methods (Hanley and Spash 1993). Demographers started to investigate the relationship between resource scarcity, population growth and migration. Decision theorists tried to develop new tools for policy-making that were more tuned to the often qualitative and unpriced nature of environmental goods (such as multicriteria and multi-objective decision tools). Many disciplines worked together in integrated modelling and assessment, addressing both ecosystems and global scales (climate). Finally, statisticians got involved in the formidable task to develop new statistical data that would map out and monitor energy use, environmental deterioration and the like. So in some twenty-five years time here has been an explosive interest among social scientist in environment and resource issues.

It should be noted that there are many ways for a simultaneous analytical treatment of economics and environment. Since the 1960s a great many attempts has been made to link the economy to the ecology (Costanza *et al.* 1997). An important contribution to the integration of economics and ecology began simply with a reflection on the principles of the materials balance for resources (extracted or collected, transformed, consumed and emitted) and on the need to take account of an economic viewpoint of such processes (Ayres *et* al. 1999). Several attempts have also been made to build economic and social accounting systems that could incorporate the measurement of economic welfare and performance together with the measurement of environmental indicators and performances. The integration of economics with ecology has also been approached from the viewpoint of land-use – where economic and ecological processes have the most disruptive effects – and of urban environments. In

addition, the interaction between economics and ecology has next been dealt with for situations with global risks and uncertainties.

In the past decade one can observe an avalanche of publications on environmental issues, not only in popular journals, but also in academic publication channels (journals, books). Most of these publications demonstrate clearly the multidisciplinary nature of environmental sciences, which caused researchers from various disciplines to cooperate, with more or less success. Especially the field of 'ecological economics' (and its journal with the same title) has shown the need for multidisciplinary thinking, even in environmental and resource economics.

3. A Short Account of Core Topics

In this section we will offer a concise overview of major topics in the area of management and economics of environment and resources. These issues are covered in detail in van den Bergh (1999). A very readable introduction is Kahn (1998), while a thorough treatment is provided by Perman *et al.* (1999).

A major focal point with already a long tradition is - as mentioned above - *natural resource management,* for both renewable and non-renewable resources (Clark 1990; Dasgupta and Heal 1979). Questions analyzed in this context concern optimal extraction of non-renewable resources under competitive conditions (such as the well-known Hotelling cake-eating choice dilemma). In the literature on these issues much attention is given to the (as yet uncertain) options offered by technological innovations and to the statistical uncertainty in estimating the resource stock (so far all estimates appeared to be rather conservative). This relates to the problem that the correct way of measuring resource scarcity is subject to debate, and has given rise to a range of scarcity indicators. From a management perspective, much attention has also been devoted to the implications of limited competition (e.g., monopolistic and oligopolistic market forms). Also renewable resources have gained much interest, in particular in the agricultural, fishery and forestry sector. Important issues here are uncertainty, re-investment rules and multiple-use conditions amongst others. Finally, in recent years we have observed an intensified interest in two particularly important resources with a wide societal and global coverage, viz. water and energy. These two resources are important concerns in both the developed and the developing world, not only because of their immediate far reaching implications of emerging scarcity but also because of the changing markets of these goods towards more deregulation and privatization.

A recurrent theme in environmental and resource economics is the *economic valuation and evaluation of environmental goods,* such as clean air or water. The main problem here is the non-priced nature of many environmental goods, so that the environment runs the risk to be forgotten in any cost-benefit analysis for plan or project evaluation. The question is then whether it is possible to restore a missing market, e.g., by introducing shadow prices via taxation schemes or otherwise on an artificial market, or to edict regulations to ensure at least a minimum respect for environmental goods, e.g., in the form of standards. Although from a market theory perspective shadow prices (including taxes and subsidies) are often regarded as superior, in practice many forms of standard stetting have emerged, as they are more

unambiguous and better testable. In the literature a wide variety of valuation approaches has been proposed. These can be categorized as: travel cost methods (based on revealed preference approaches using generalized travel costs), the contingent valuation methods (based on state preferences, i.e. experimental surveys or questionnaires), and hedonic pricing methods (based on revealed preferences related to property values). A prominent question in valuation theory is the reliability of the various price estimates. Various considerations are relevant in this respect: the strategic contents of responses to interviews or survey questionnaires; the distinction between use and nonuse values; the choice between 'willingness to pay' and 'willingness to accept compensation' measures' and scale and double-counting issues (Hanley and Spash 1993; Turner et *al.* 1999). Recently, benefits transfer and meta-analysis are used to avoid having to undertaken costly new valuation studies. For environmental policy purposes also various adjusted approaches have been developed, such as social cost-benefit analysis and multi-criteria evaluation methods. These methods have been widely applied. Nevertheless, their application faces various caveats, in particular problems associated with choosing a correct social rate of discount, incorporating spatial or temporal equity issues, and addressing problems where only qualitative or fuzzy information is available.

Another topic that makes up an indispensable component of the study of the environment and natural resources is the *geographical dimension.* Many environmental problems may seem to be local or regional issues, but have a world-wide impact. This is caused by two factors, viz. international (or interregional) trade and the spatial diffusion of pollution (or the spatial dimension of externalities in general). For example, the high efficiency of the meat industry in Western Europe is co-determined by the importance of tapioca from Thailand which leads to wide-spread environmental decay in the latter country. Phenomena like ozone layer destruction, rise in ocean levels and desertification are other illustrations of the geographically interwoven nature of the environmental problem. As a result, cross-boundary and global environmental problems have provoked much scientific debate, not only on the causes but also on the policy responses (e.g., international environmental agreements, trade regulations etc.). Such issues play also a recurrent role in negotiations on trade liberalization in the context of the World Trade Organization (WTO). In a more theoretical setting, also much attention is given to equilibrium-distorting effects of environmental externalities in international trade. Issues investigated there are the effects of imperfect competition, industrial specialization and interlinkages, consequences of unilateral environmental regulations, trade in pollutants (e.g., toxic materials) and the position of Third World countries. Cooperative and non-cooperative game strategies are inter alia studies in the context of global warming, climate change, acid rain, stratospheric ozone and global biodiversity. And finally, from a geographical perspective much attention has been paid to point versus non-point source pollution problems, land use, urban environmental issues, locational issues and transportation. In retrospect the spatial dimension of resource and environment issues have been addressed on various occasions and from different perspectives, but there is certainly still a broad research field in the geography of the environment.

Next, we will address in this section the problem of *environmental and resource policy*. The frequent absence of markets for environmental goods, i.e. a market failure, leads to a distortion in the price system and hence to an inefficient allocation which causes environmental decay, resource depletion and the acceptance of high environmental risks. There has been a formidable range of publications on environment and resource policy, in particular on the choice of policy instruments, on different taxation regimes, technical and product standards, subsidies, tradable permits, deposit-refund systems, stimulating self-regulation via covenants, and joint implementation. In economic theory efficiency has been the dominant policy selection criterion. However, in practice instrument choices will also be influenced by other criteria, such as effectiveness (relating to uncertainty, monitoring and control), equity (social and political feasibility), sustainability (ecosystem stability and resource availability) and international setting (agreements, laws and policy coordination). Various topics have been discussed in relation to the choice of instruments of environmental policy: the impact of imperfect markets, the encouragement of technological innovation and R&D, environmental tax reforms, and the role of transaction costs. Certain proposals for environmental tax revisions, or 'ecotaxes' in popular jargon, have been argued by some to create a double dividend, that is, a beneficial outcome for both environment and employment. In general, however, economists are very sceptical about the existence of 'win-win' (or 'no-regret' or 'low-fruit picking') policies. This is partly related to the inevitable intra- and intertemporal efficiency-equity trade-offs in policy analysis, which have received much attention in the context of welfare theory, relating to both utilitarian principles and Rawlsian theories of justice. Finally, in the past few years we have witnessed a large flow of scientific contributions on international agreements and negotiations regarding transboundary or global environmental and resource issues. Harmonization of international regulations appears to be still a field fraught with many conflicts and divergent policy strategies.

As a last topic, the *scientific apparatus* developed to come to grips with the complexity of the new scarcity will be mentioned. Standard monodisciplinary approaches cannot always be applied in a straightforward manner, as always multiple dimensions and disciplines have to be taken into consideration. Examples range from lessons obtained from thermodynamic theory to marketing principles being applied to eco-labeling. Mass balance knowledge is needed to undertake life cycle analysis, and analogies of ecosystem models may be used in the context of 'industrial metabolism'. It is therefore no surprise that a uniform analysis framework has not emerged. On the contrary, we observe a great diversity of methods and models. Some important classes are: input-output and materials balance models; optimal control and dynamic programming models; partial and general equilibrium models; policy evaluation methods such as cost-benefit and multi-criteria analysis; game theoretic models; resource extraction models; natural resource accounting methods; evolutionary and other dynamic simulation approaches; meta-analysis; and experimental methods.

The previous overview has also clearly highlighted the need for proper communication in the environmental sciences. Progress - in terms of new insights and impacts on policy - will only be made if environment and resource issues are jointly analyzed from common themes in.., research.

4. Towards a Sustainable Environment

Doomsday prophets have spent much time on building an image of the world where environmental deterioration would herald apocalyptic perspectives. It is surprising to note that in many parts of the world we have seen a recovery of threatened ecosystems and environmental quality conditions as a result of active policy intervention, technological progress and behavioural change. It seems as though economic growth is not necessarily at odds with environmental sustainability.

Environmental sustainability is often distinguished into weak and strong sustainability. 'Strong' refers to the idea that every component of the environment and nature has to be maintained, with 'Deep ecology' as its most extreme proponent. 'Weak' refers to a change that makes some environmental components worse off, provided that the overall net balance is still positive. The distinction relates to ethical positions as well as views on the possibility of substitution (as opposed to complementarity) between nature or environmental goods and services on the one hand and socio-economic artefacts on the other hand. The question of weak and strong environmental sustainability is also co-determined by the degree of disaggregation of the environmental system under consideration, by the geographic scale at which environmental problems are studied, and by the time horizon.

The notion of sustainable development is related to the old debate on growth versus environmental protection (Daly and Townsend 1993). In the context of endogenous growth theory it seems plausible that economic progress may be accompanied by environmental quality improvement, provided a sufficient part of public and private expenditures is allocated for environmental protection measures, for environmental investments and for environmental R&D. This has inspired a debate on sustainable growth. Clearly, such a discussion can only lead to conclusive answers if it is supported by empirical facts. This discussion on the 'decoupling' or 'delinking' hypothesis has laid the foundation for the so-called 'environmental or green Kuznets' curve, where the underlying assumption is that after a stage of environmental decay as a result of economic growth a new stage may set in during which economic growth may support a more environmental benign development. This growth optimism however, is thus far not yet supported by sufficiently reliable statistical data, although it is clear that there are many examples of environmental improvement in a growing economy. But the green Kuznets curve does certainly not hold for all environmental indicators. A related important issue is the attempts to correct the conventional measure of welfare, GDP per capita, for environmental decay. Although this would not lead to a perfect indicator of welfare or progress, it could render a much better indicator for public and private decision-making, notably by central banks, international financial institutions, and financial markets.

Just as the academic interest in environmental problems has evolved so has the institutional setting in which they are addressed. There has been a movement away from micro-policy making in the hands of city councils, regional public bodies, and the like, to macro-policy making, involving global agencies such as the United Nations and World Bank..,.

Indeed, one of the pressing issues of contemporary environmental debate is the appropriate jurisdiction for different levels of government.

It is thus clear that the concept of sustainable development has been the source of much creative environmental research in the past years. But did it also have effective implications for environment and resource management?

5. Concluding remarks

Environmental analysis extends across virtually all academic disciplines. Indeed, many disciplines such as economics and engineering have specific sub-areas of interest specifically devoted to environmental issues. The multidisciplinary and transdisciplinary nature of environmental research makes it difficult to keep track of the key literature.

In a few decades time, an overwhelming amount of research efforts and research findings on environment and resource issues can be observed. Environmental science has become a rapidly evolving field with a strong social science component. Environmental and resource economics has generated many insights about environmental policy design, natural resource management, development and growth policies, international trade and environment, transboundary pollution issues, and international agreements and policy coordination.

A rapidly evolving field is environmental business management (sometimes referred to as 'environmental management', or 'business and the environment'). This brings together scientific insights and business experiences. Many firms, especially larger ones, have accepted the importance of environmentally sustainable action and strategy, for various reasons. It has not only led to many in-house adjustments (waste treatment, environmental accounting, internal organization), but also to strategic decisions about 'green marketing', eco-labeling, investments, and involvement of various stakeholders. So far, however, a close link with the theoretical and empirical literature in traditional environmental and resource economics is lacking. An fundamental and long-standing question that their synergy could resolve is how firms make decisions about environmental management in complex and international situations, dominated by multiple stakeholders, rapidly changing markets, and new information and communication technologies. This could provide information on what type of environmental regulation is most effective and efficient in the long run.

In conclusion, resource and environmental economics has created a breadth and depth of scientific insights into the new scarcity. Both theoretical and empirical knowledge has been generated in a surprisingly rapid pace. Its multidisciplinary orientation has offered a great strength to this relatively young discipline to attack complex and topical policy issues.

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