FORMAL ENVIRONMENTAL EDUCATION AT THE GRADUATE LEVEL

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Contents

Summary

As future leaders of society, and certainly as stakeholders in the well-being of the natural environment which is unquestionably the unique resource base for wealth creation, it is important for *all* graduate students to know about Earth's natural environment, about how human behaviour and activities have been relentlessly harming it, and about what ought to be done through higher education and research to arrest or if possible reverse the trend. Yet, even a cursory examination would reveal that, despite mounting scientific evidence of how anthropogenic pollution has been degrading the natural environment with potentially catastrophic consequences for future generations, at present formal environmental education at the graduate level falls short of what it ought to be, especially in non-environmental Masters degree programmes. It is also a matter of concern that while methods and strategies for pollution reduction and prevention are a priority, in the EU hierarchy of waste management options, for example, the so-called 'end-of-pipe' methods and strategies for dealing with pollution *after* it has been created continue to be emphasised in both environmental Masters Degree programmes and environmental research.

With a view to addressing these deficiencies, specific environmental subjects are proposed in this contribution as part of the formal curricula of graduate study programmes, and a number of research areas identified as priority. Some of the related

issues are also discussed.

1. Introduction

1.1. The background in brief

A disturbing question, which underscored deliberations at the World Summit on Sustainable Development (WSSD) (Hens and Nath, 2005) held in Johannesburg from 26 August to 4 September 2002, was this: why, in spite of all the money and effort expended during the ten-year period from Rio (1992) to Johannesburg (2002), the world of 2002 was environmentally less sustainable than in 1992? What went wrong? The response to this question was, and is, predictable. While the poor developing countries argued that their efforts to meet Agenda 21 objectives had been seriously thwarted by lack of financial and skilled manpower resources, in general the rich developed countries appeared to be reasonably content with the progress they had made notwithstanding the refusal of the USA to ratify the Kyoto Protocol.

However, this 'progress' warrants close scrutiny. We argue that it is suspect and misleading too. Because, whatever progress the developed countries have so far made towards meeting the Agenda 21 objectives has largely been achieved with systematic relocation of their 'dirty' manufacturing facilities to poor developing countries that have little or no bargaining power, where labour is cheap and abundant, and the regime for enforcing environmental standards and regulations is lax or can be manipulated with inducements. Largely as a result of relocation today, the manufacturing sector of the US or the UK economy, for example, accounts for only about 20% of their respective GDPs and is shrinking. If this trend continues—and it is more likely than not to given the gathering pace of globalisation—in about 20 years from now these macroeconomies are likely to be based almost entirely on the service sector. However, relocation of manufacturing facilities in this way cannot address the growing problem of global anthropogenic pollution—it merely changes the jurisdiction of the pollution, from the 'rich' world to the 'poor' world. And, as regional and national environmental pollution often becomes, or contributes to, global pollution affecting all, this state of affairs does not augur well for the long-term integrity of the global environment or for nature's life support systems without which life on Earth cannot exist. As a result environmental contamination continues to be so relentless and so comprehensive that today it is hard to find a single aspect of the natural environment that has not been adversely affected by human activities. Typically, thanks to humankind's headlong drive for economic development based on industrialisation, scientists predict that the mounting problems of global warming and climate change have potentially catastrophic consequences for life on Earth unless urgent action is taken to reduce anthropogenic CO_2 emissions (e.g. ISSC, 2005; McCarthy, 2005; Royal Society, 2005).

1.2. Why is it important for graduate students to know about the environment and current status of environmental education at the graduate level

Graduate students (see Glossary) represent the intellectual 'cream' of any society. In due course most of them become politicians, decision-makers, research scientists, leaders of business and industry, and so on. In these capacities they are expected to

discharge their professional responsibility in ways that protect the environment, promote sustainable development and improve people's quality of life without irreversibly degrading the natural environment and/or profligately depleting Earth's limited natural resources, so that the ability of future generations to meet their own needs is not compromised (WCED, 1987). Clearly, in order to be able to do so, they must have a good grounding in environmental protection and sustainable development. Furthermore, like everyone else in society, graduate students are also stakeholders in the natural environment and life-support systems that support and sustain life. It follows, therefore, that they also ought to know about the natural environment at large; in particular about how the natural environmental capital is being adversely affected, and scarce natural resources being depleted, by the life-styles and attitudes of the affluent between and within nations increasingly characterised by their apparently insatiable lust for open-ended consumption and profligacy (Nath, 2003; Nath and Kazashka-Hristozova, 2005). More importantly, it is their responsibility to ascertain through study and research what needs to be done to arrest and if possible reverse the current trend of environmental degradation. Unfortunately, at present education in such topics appears to be almost entirely absent in non-environmental graduate programmes, as an examination of the web pages of a randomly selected sample of such programmes would confirm.

Of particular concern is the absence of such topics in graduate programmes in Law, Economics and Business Management, because in most countries these are the backgrounds of by far the majority of politicians and decision-makers. Typically, topics in environmental protection or sustainable development appear to be absent in MBA programmes. For example, students in the 21-month MBA programme at the London Business School of the University of London, which is ranked in the top ten business schools in the world by the *Financial Times*, are required to take 16 core courses followed by 12 elective courses to be chosen from around 70 on offer. Yet, not a single one of these courses appears to be remotely concerned with environmental protection or sustainable development. Another example is provided by the MBA programme of the prestigious Vlerick Leuven Gent Management School in Belgium. Once again no subject on offer is remotely concerned with these topics. Generally, this deficiency is to be found in graduate programmes in Law and Economics, too, but not in Environmental Law or Environmental Economics programmes which appear to address the issues of environmental protection and sustainable development, albeit almost exclusively from the 'end-of-the-pipe' standpoint.

This state of affairs is a little strange, because in due course many if not most of the MBA graduates would be responsible for managing and leading business and industrial concerns, and that these concerns have been, and are, responsible for increasing contamination of air, water and soil as well as for generating increasing quantities of industrial waste to be safely disposed of. Directly and indirectly such enterprises are also responsible for generating ever-increasing quantities of post-consumption waste to be safely disposed of. Of course, one could argue that a major business or production facility will have its own Environmental Manager whose job is to ensure that the organisation complies with relevant environmental regulations in force. But then, major corporate policy is made by the Executive Directors of an enterprise, not by its Environmental Manager, and policy is nearly always concerned with improving the

enterprise's 'bottom line' and seldom with achieving or promoting sustainable development. Indeed, experience shows that although there are exceptions, corporate policy generally tends to comply as minimally with environmental standards and regulations in force as they can get away with. (In any case, environmental standards, such as they are, cannot deliver environmental sustainability or sustainable development; see section 3.2.3). The neglect of these subjects, especially in MBA programmes, as appears to be the case, is indicative of the very low priority (or perhaps disdain) which the business and industrial communities appear to attach to environmental protection and sustainable development. It is hard to see how future leaders of business and industry could make corporate policy conducive to environmental sustainability or sustainable development without having at least a working knowledge of the pertinent environmental issues and problems and how they ought to be addressed.

Currently teaching of environmental subjects at the Masters level tends to emphasise 'end-of-the-pipe' methods and strategies in the problem-solving mode to deal with anthropogenic pollution already created. This is a major deficiency because, where appropriate and feasible, emphasis really needs to be on 'before-the-pipe' methods and strategies too. This is because waste reduction and waste prevention are a priority, for example in the EU hierarchy of waste management options (e.g. Powrie and Robinson, 2000). Ideally, there would be no need to treat waste (or to deal with the impacts of anthropogenic contaminants) if it is not created in the first place.

2. Sustainable development and related issues

2.1. Sustainable development and environmental sustainability

In the Brundtland Commission Report, *Our Common Future*, the authoritative definition of sustainable development is given as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (WCED, 1987, page 8).

Demonstrably, nature's bountiful benediction of resources (e.g. minerals, fossil fuels, air, water, soil fertility, biodiversity, etc.) provides the unique resource base for wealth creation through economic development. However, as that resource base is not inexhaustible and can be degraded, it follows that there must exist some as yet unknown limit beyond which environmental degradation and exploitation of natural resources to supply the open-ended and increasingly profligate demands of the present generation for goods and services will compromise the ability of future generations to meet their own needs. Thus, prudent use and husbandry of natural resources in ways that do not degrade the natural environment, or seriously deplete the natural resource base commensurate with nature's cyclic renewal and capacity for regeneration, is implicit in the above definition. Clearly therefore, sustainable development is firmly and inextricably linked to sustainability of the natural environment (generically referring to nature's resource base including life support systems) in the sense that sustainable development is economic development that exclusively relies upon and is firmly and inextricably rooted in the integrity and sustainability of the natural environment. In other words sustainable development, which is after all a particular type of economic development, can only derive from a healthy and sustainable natural environment and nature's vital life support

systems. This is tangentially reflected in Article 2 of the Treaty of the European Union (TEU) (1992), "….environmental policy objective to include the goals of sustainable and non-inflationary [economic] growth respecting the environment" (Lee, 1994). Clearly, if nature's resource base is irredeemably depleted or irreversibly degraded, the means of wealth creation for social welfare will be seriously jeopardised and the notions of inter-generational and intra-generational equity will be little more than hollow. Unfortunately, experience shows that in the environmental community there are many who do not understand the true meaning of sustainable development, which is in the above sense, and sustained and non-inflationary economic growth *per se* is sometimes confused by many with sustainable development without any reference to environmental sustainability. There is also confusion between sustainable development and quality of life.

Which should then come first, environmental sustainability or sustainable development? To answer this question, think of Earth's natural environmental capital as a 'cow', and its 'milk' as the benefit and welfare derived from that capital through economic development. Clearly, if the cow is not well looked after, or abused and milked beyond its capacity, it will become sick and may even die, and there will be little or no milk as a result. We argue, therefore, that global environmental sustainability must take precedence over global sustainable development which is after all a particular paradigm of economic development.

2.2. Heuristic for an operational definition of sustainable development

The definition of sustainable development given in the Brundtland Commission Report, *Our Common Future* (WCED, 1987), is political, as is the Report itself. And it is proving to be a huge challenge to translate it into an operational definition for practical implementation. At present there is no unique operational definition of sustainable development. Neither is there a single, compound indicator like GDP (Gross Domestic Product) in macroeconomics for comparing relative progress made by different countries or regions towards environmental sustainability or sustainable development, or for monitoring progress towards them made by a given country or region over time. The lack of a unique operational definition of sustainable development has spawned a veritable 'industry' devoted to developing such a definition with the result that today there are more than 200 different definitions of sustainable development. Most of these are of the 'do-it-yourself' kind designed to suit or promote specific developmental goals or circumstances, although the serious ones are basically repackaging of the Brundtland Commission definition and convey more or less the same meaning. This lack has been impeding progress towards global sustainable development and environmental sustainability. Certainly, from the educational point of view a unique operational definition is essential because without it students become confused and tend to lose interest, as experience shows.

Sober contemplation would reveal that the apparently insatiable lust of the affluent between and within nations for open-ended consumption of goods and services is mostly to blame for the environmental predicament confronting humankind today. It is acknowledged in *Our Common Future* which advocates, "Sustainable development requires that those who are more affluent adopt life-styles within the planet's ecological

means in their use of energy for example" (WCED, 1987; page 9).

"The world manufactures seven times more goods today than it did as recently as 1950. Given population growth rates, a five- to ten-fold increase in current manufacturing output will be needed just to raise developing-world consumption of manufactured goods to industrialised world levels by the time the population growth rates level-off next century" (WCED, 1987, page 15).

'Today' above refers to 1984. Today (2006) that factor is more than seven, probably ten or eleven. It is now acknowledged that unfettered growth in production and consumption of goods and services, which the prevailing *laissez-faire* economic system demands for its smooth functioning, is the main obstacle to the achievement of even a modest degree of global sustainable development or environmental sustainability (e.g. Martinez-Alier, 1993 and 1997; Nath, 2003). We also note that while the authoritative definition of sustainable development is in terms of 'needs' (WCED, 1987, page 8), the prevailing economic system is increasingly geared to supplying the 'wants' of the affluent, not to mention their ever more fanciful pursuits for instant sense-gratification. Arguably, insatiable lust of the affluent for open-ended consumption of goods and services is the 'deep malaise' whose symptoms are the environmental problems confronting us (Nath, 2003). The following excerpt from the *Living Planet Report 2000* (WWF, 2000) concentrates the mind well:

"Man has wiped out a third of the natural world in the last thirty years and soon will have to start looking for a new planet to live on……The scale of devastation is so great that man will have used up all the Earth's natural resources by 2075…..If every human alive today continues to consume resources and produce carbon dioxide at the same rate as the average Briton, we will need to colonise at least two Earths to survive…..Our current consumption is eroding the very fabric of our planet and will ultimately threaten our long-term survival".

It is clear from the above that the core requirement of sustainable development is diametrically opposed to the fundamental condition for the smooth running of the prevailing *laissez-faire* economic system. Therefore, achievement of global environmental sustainability (or global sustainable development) within the framework of the prevailing economic system is not unlike trying to fit a square peg in a round hole. Yet, efforts must be made to reconcile this improbable juxtaposition of opposites by reducing consumption, especially by the affluent, and by making necessary changes to the economic system. We do not pretend that the exercise is going to be easy. Certainly not, for human desire for open-ended consumption strongly resonates with our innate aspiration for ever rising standards of living which in most cases translates into acquisition of ever greater wealth and material possessions. Neither is it new; even the ancient Greeks knew about the utility of open-ended consumption (for example, in *The Wealth* by Aristophanes (c.450 – c.385 BC)). We also note that according to Darwin, a species cannot survive (and perhaps does not deserve to) if it cannot adapt to changes to its environment and/or circumstances. Therefore, if the international community is at all serious about achieving even a modest degree of global environmental sustainability (and therefore global sustainable development), global consumption of goods and services must be reduced; there must be more equitable distribution of wealth and

resources between and within nations; sustainability should be defined in terms of reduced consumption; and a simple, universal indicator like GDP in macroeconomics developed in terms of reduction in consumption.

3. Proposal for the environmental curricular content for graduate students

3.1. Masters degree programmes

Global environmental sustainability (and global sustainable development) is not so much 'a problem out there' to be 'solved' for its achievement. Rather, it has to do with our mind and mindset—it is a function of our attitude and behaviour to nature and the natural environment and of how we relate to them. Indeed, how we treat nature and the natural environment (and anyone or anything for that matter) is largely determined by our attitude to them, and our attitude in turn is shaped by the moral and ethical values we hold (Nath, 2003). Therefore, at all levels the objective of environmental education ought to be to engender a change in learners' attitude to nature and the natural environment, from one of gross exploitation as at present to that of *genuine* care, concern and respect. It is hard to see how science and technology however advanced, or command-and-control public policy however rigorously enforced, could bring about such a change. What is needed is education in moral and ethical philosophy, because it is morality and ethics that shapes our attitude, behaviour and how we perceive the world around us. With this in mind and acknowledging that 'end-of-the-pipe' and 'before-the-pipe' methods and strategies ought to be equally emphasised where appropriate and feasible, Table 1 gives a proposal for the generic curricular content for the Masters level. It is based on the generic outline syllabus given in Box 2 of *Curricula Development for Undergraduate University Students*. But clearly, treatment of the subjects should be at a higher level and greater depth than for undergraduate students.

Discipline	**Proposed subjects to be taught** (one subject to be developed from each item of Box 2, Topic 4.16.2.1, indicated below)
Engineering Civil, mechanical, chemical, production, and electronic and electrical engineering	(B), (C), (D)
The exact sciences Mathematics, physics, chemistry, biology, astronomy	(B), (D)
The social sciences Law (excluding environmental law), economics (excluding environmental economics), business and management studies, politics, geography	(B), (D)
Environmental law and environmental economics	(B)

Table 1. Proposed subjects for the environmental education of graduate students

In addition, group discussion and brain-storming should be organised on topical environmental issues and problems. Experience shows that when properly organised, these events bring considerable benefits in terms of appreciation of the environmental problems confronting societies today, what could be and should be done to address them, and the likely consequences of doing nothing.

Using basic mathematics, a simplistic mathematical model is given in the Appendix to explain how, exacerbated by 'positive feedback', Earth's self-regenerative capacity (SRC) is eroded by anthropogenic pollution. If deemed appropriate, Masters degree students should be encouraged to study the model and to improve it as a part of their coursework. This can bring significant academic benefits, as experience shows.

3.2. Topics for research

Scientists engaged in research in a certain disciplines tend, sometimes by the very nature of their work, to specialise in a relatively narrow area of that discipline. In most cases this leads to a kind of 'tunnel vision' which emphasises narrow, individual areas of special interest and denies a proper perspective on the totality of the problem of which such individual areas are but components, usually small or very small. This does not accord with the real world of the environment which functions as a delicately balanced 'organic whole' comprising a multitude of interacting and inter-dependent elements, not one of which can be or should be manipulated or studied by ignoring its effects on the others. In other words environmental research should be holistic, which it is largely not at present.

With regard to the above and *Some Pressing Global Environmental Problems of Our Time and Strategies for Mitigating Their Impacts*, holistic (as far as feasible) research is suggested in the following topics as the priority, aiming to enhance the prospects of global environmental sustainability and true global sustainable development.

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Bibliography

BBC (2006). "Urgent call on carbon emissions", News broadcast on 11 September, London, the British Broadcasting Corporation. [This news item was on a Report of the Tyndall Centre for Climate Change Research, based at the University of Manchester, in which climate scientists warned that greenhouse gas emissions must be reduced by 70% by 2030 to avoid far-reaching consequences of climate change that have serious implications for life on Earth].

BISHOP R.H. and DORF R. (2004). *Modern Control Systems*, New York, Prentice-Hall. [This text explains modern control systems widely used in manufacturing and process industries including latest developments and the phenomena of positive and negative feedback].

CARLSON A.B. and GISSAR D.G. (1990). *Electrical Engineering: Concepts and Applications* (second edition), New York, Addison-Wesley. [This text, which is meant for students of electrical engineering, also explains the phenomena of positive and negative feedback from the perspective of electrical engineering].

DALY H. (1971). "Toward a Steady-State Economy", In *The Patient Earth*, (Eds.) J. Hart and R. Socolow, Austin, Texas: Holt, Rinehart and Winston. [In this contribution the author argues that under the *laissez-faire* economic system economic growth is not compatible with environmental quality because unfettered economic growth adversely impacts on the natural environment, and therefore that a steady-state in production and consumption needs to be achieved for sustainability].

GEORGESCU-ROEGEN N. (1971). *The Entropy Law and the Economic Process*, Cambridge, Mass: Harvard University Press. [Invoking the concept of entropy in thermodynamics and depicting the economic process as a circular diagram within a completely closed system, the author argues that Earth's ecological resources can support uninterrupted economic growth. This paradigm is akin to Karl Marx's famous model of production in which the economic process is represented as completely circular and self-sustaining].

GOLDSMITH E. (2003). "Rewriting economics", *Journal of the LSE Environmental Initiatives Network*, Vol. 7, London School of Economics. [In this interesting article the author explains why neoclassical economics produces a distorted view of our relationship with the real world in which we live].

HENS L. and NATH B. (eds.) (2005). *The World Summit on Sustainable Development: The Johannesburg Conference*, Dordrecht, The Netherlands, Springer. [This book gives an overview of the most important issues dealt with in the *Johannesburg Plan of Implementation* which is one of the key outcomes of the World Summit on Sustainable Development (WSSD) held in Johannesburg in 2002. The issues addressed include poverty, production and consumption patterns, education, water and energy. The book offers a unique framework to follow up and evaluate the progressing international discussion on sustainable development].

ISSC (2005). *Avoiding Dangerous Climate Change*, Report of the International Scientific Steering Committee (ISSC), Hadley Centre, Met Office, Exeter, UK. [This report, prepared by the ISSC, summarises the findings as presented to the International Symposium on Stabilisation of Greenhouse Gas Concentrations (called the Climate Change Conference for short) held at Exeter, UK, during 1 and 3 February 2005. It brought together over 200 participants from some 30 countries including many leading climate scientists and experts in climate change. The Report paints a gloomy picture of what might happen to ecosystems, the global economy, and to human societies if urgent actions are not taken to curb man-made CO_2 emissions significantly].

LEE N. (1994). "Environmental Policy", in M.J. Artis and N. Lee (eds.), *The Economics of the European Union*, Oxford, University Press, pp. 238-268. [This chapter gives a comprehensive account of the European Union's environmental policy].

LOVELOCK J.E. (1986). *Gaia: The World as a Living Organism*, New Scientist, Vol. 112, pp. 25-28. [In this paper the author introduces the Gaia Hypothesis (after *Gaia* or *Gaea* the Greek Goddess of the Earth) according to which we are parts of a greater whole, and our destiny is not determined only by what we do for ourselves but also by what we do for Gaia].

LOVELOCK J.E. (1995). *Gaia: A New Look at Life on Earth*, Oxford, Oxford University Press. [In this interesting and highly readable book written for non-scientists, the author argues that life on Earth functions as though it were a single organism].

MARTINEZ-ALLIER J. (1987). *Ecological Economics: Energy, Environment and Society*, New York, Basil Blackwell. [In this book the author describes what he calls 'Ecological Economics' which, he argues, is more attuned to and consistent with the fundamental requirements of environmental sustainability and sustainable development than the prevailing *laisssez-faire* economic system].

MARTINEZ-ALIER J. (1993). "Steps towards an ecological economy", in Proc. *Conf. Env. Poll. (ICEP-2)*, Vol. 2, pp.497-500, London, European Centre for Pollution Research. [In this paper the author argues that if development is defined in terms of economic growth, then the concept of sustainable development becomes questionable, perhaps even a contradiction in terms of the environment, unless of course growth can be shown to be beneficial, or at least not damaging to the environment. However, in its conventional sense economic growth and the manner in which it is pursued and achieved is mostly not beneficial to the

environment and often damaging to it].

McCARTHY M. (2005). "Global warming: scientists reveal timetable", *The Independent*, 3 February, London. [Based on the deliberations at the International Conference on Climate Change, held in Exeter (UK) in February 2005, this article gives a detailed timetable of the destruction global warming is likely to cause to Earth's ecosystems and to all life generally, if the world community persists with the business-as-usual scenario].

NATH B., TALAY I. and TANRIVERMIS (1998). "Proposed methodology for the calculation of a local sustainability indicator", in *Research in Human Ecology: an Inter-Disciplinary Overview*, (Eds.) L. Hens, R.J. Borden, S. Suzuki and G. Caravello, Brussels, VUB Press, pp. 143-168. [A novel method is proposed in this paper for measuring sustainability achieved by a local community using a combined index in which both quality of life and environmental sustainability are factored in].

NATH B. (2000). "Some issues of intragenerational and intergenerational equity and measurement of sustainable development", in B. Nath, S.K. Stoyanov and Y. Pelovski (Eds.) *Sustainable Solid Waste Management in the Southern Black Sea Region*, Kluwer Academic Publishers, Dordrecht, the Netherlands, pp. 1-26. [Some of the major issues of sustainable development are discussed in this paper which also presents a novel method of measuring sustainable development at the local level].

NATH B. (2002). "Environmental regulation and standard setting", in *Knowledge for Sustainable Development—an Insight into the Encyclopaedia of Life Support Systems*, Paris, UNESCO. [This publication gives a comprehensive account of environmental regulations and standards including their limitations for controlling anthropogenic pollution].

NATH B. (2003). "Education for sustainable development: the Johannesburg summit and beyond", in B. Nath, L. Hens and D. Pimentel (eds.), *Environment, Development & Sustainability*, Vol. 5, pp 231-254, Dordrecht, Kluwer. [Contains a survey of environmental education including recommendations of the Johannesburg Plan of Implementation (JPoI) and advocates inclusion of moral and ethical philosophy *vis-à-vis* the natural environment in formal educational curricula as an essential pre-requisite for achieving global sustainable development].

NATH B. and KAZASHKA-HRISTOZOVA K. (2005). "*Quo vadis* global environmental sustainability? A proposal for the environmental education of engineering students", *Int. J. Env. Poll.*, Vol. 23. No.1, pp. 1-15 [In this paper the authors demonstrate the futility of exclusive reliance on science and technology to deliver sustainable development and argue that moral education is needed for this to change human attitude to nature and the natural environment—from one of gross exploitation as at present to that of genuine respect].

NATH B. (2006). "A heuristic for setting effective standards to ensure global environmental sustainability", *Environment, Development & Sustainability*. [In this paper the author argues that as a biogeochemical organism the Earth has limited self- regenerative capacity (SRC) which, when exceeded, creates all kinds of environmental problems as at present. Therefore, environmental standards would be effective if and only if they are set so that anthropogenic pollution does not exceed Earth's natural SRC].

PIMENTEL D., HARMAN R., PACENZA, M., PECARSK J. and PIMENTEL M. (1994). "Natural resources and optimum human population", *Population and Environment*, Vol. 15, pp. 347-369. [In this paper the authors consider and try to relate the natural resources of a habitat to the optimum human population it can support commensurately with its 'carrying capacity'].

OXFAM (2002). *Rigged Rules and Double Standards—Trade, Globalisation, and the Fight Against Poverty*, London, Oxfam International. [In a determined campaign to make trade fair between rich and poor nations, this publication focuses on how current international trade and aid arrangements have been further impoverishing the poor nations and makes proposals for how they should be changed in the interests of fairness and equity].

PILGER J. (2002). *The New Rulers of the World*, Verso, London. [In a collection of extended essays and earlier original work, in this book the author illuminates the nature of modern imperialism. He discloses, among others, how up to a million Indonesians died as a price for being the World Bank's "model pupil", and the price paid by the people of Iraq for the West's decade-long embargo on that country].

PLANCK M. (1963). *The Philosophy of Physics*, New York, W.W. Norton. [Original edition published in 1936, this book explores the philosophical implications of new physics, quantum physics in particular,

starting from the hypothesis that energy E is distributed according to the equation E = n(hν) in which n is an integer, ν frequency of light, and h Planck's constant].

POWRIE W. and ROBINSON J P. (2000). "The sustainable landfill bioreactor: a flexible approach to solid waste management", in B. Nath, S.K. Stoyanov and Y. Pelovski (Eds.) *Sustainable Solid Waste Management in the Southern Black Sea Region*, Kluwer Academic Publishers, Dordrecht, the Netherlands, pp. 113-140. [In this contribution the authors describe the design and operation of a novel landfill, conceptually based on the process of controlled decomposition and managed as a large-scale bioreactor. Relevant and up-to-date EU directives on waste are also described].

RAE A.I.M. (1993). *Quantum Mechanics*, Third Edition, Bristol, Institute of Physics Publishing. [This book gives a lucid treatment of the fundamental equations of quantum physics and the philosophical aspects and conclusions that emerge from them including *subjectivism*, *logical positivism* and the *theory of many worlds*].

ROYAL SOCIETY (2005). *Ocean acidification due to increasing atmospheric carbon dioxide*, London, The Royal Society. Internet version available at www.royalsoc.ac.uk [This authoritative report by the prestigious Royal Society of London and based on the findings of the Royal Society Working Group on Ocean Acidification paints a gloomy picture of how delicately balanced oceanic ecosystems may be irreparably damaged by ocean acidification if current carbon dioxide emission trends continue. Draws attention to the urgent need to reduce current man-made CO_2 emissions before it is too late].

SCHRÖDINGER E. (1957). *Science, Theory and Man*, London, Dover Publications, Allen & Unwin. [Original edition published in 1935, this book contains the author's Nobel address and charts the development of quantum physics. Also describes some of the philosophical conclusions emerging from quantum physics concerned with consciousness and nature of man].

TURNER R.K., PEARCE D. and BATEMAN I. (1994). *Environmental Economics*, Hemel Hampstead, Harvester Wheatsheaf. [In this book the authors assess environmental degradation being caused by economic activities and suggest changes to the *modus operandi* of the prevailing *laissez-faire* economic system to slow down, halt or reverse it].

WCED (World Commission on Environment and Development) (1987). *Our Common Future*, Oxford, Oxford University Press. [This remarkable document is the report of the Brundtland Commission established by the United Nations in the mid 1980s. It gives much useful data on the state of the global environment and urges nation states to adopt the modalities of sustainable development which, it argues, is the only kind of development that has potential for ensuring a sustainable quality of life for both present and future generations].

WORLD WILDLIFE FUND (WWF) (2000). *The Living Planet Report 2000*, London. [This Report is on the state of the global environment in 2000. It paints a gloomy but plausible picture of environmental consequences if we continue with environment-degrading and unsustainable patterns of development].

Biographical Sketch

Professor Bhaskar Nath received his Bachelor's degree in Civil Engineering from the Indian Institute of Technology, Kharagpur, India, in 1960, followed by a Ph.D. degree from the University of Wales, UK, in 1964. In 1983 he was awarded a D.Sc. degree by the University of London for his outstanding original research (according to citation) in numerical mathematics. In 2001 he was awarded the Doctor Honoris Causa (Dr.H.C.) by the University of Chemical Technology and Metallurgy, Sofia, Bulgaria, for his contribution to environmental education.

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