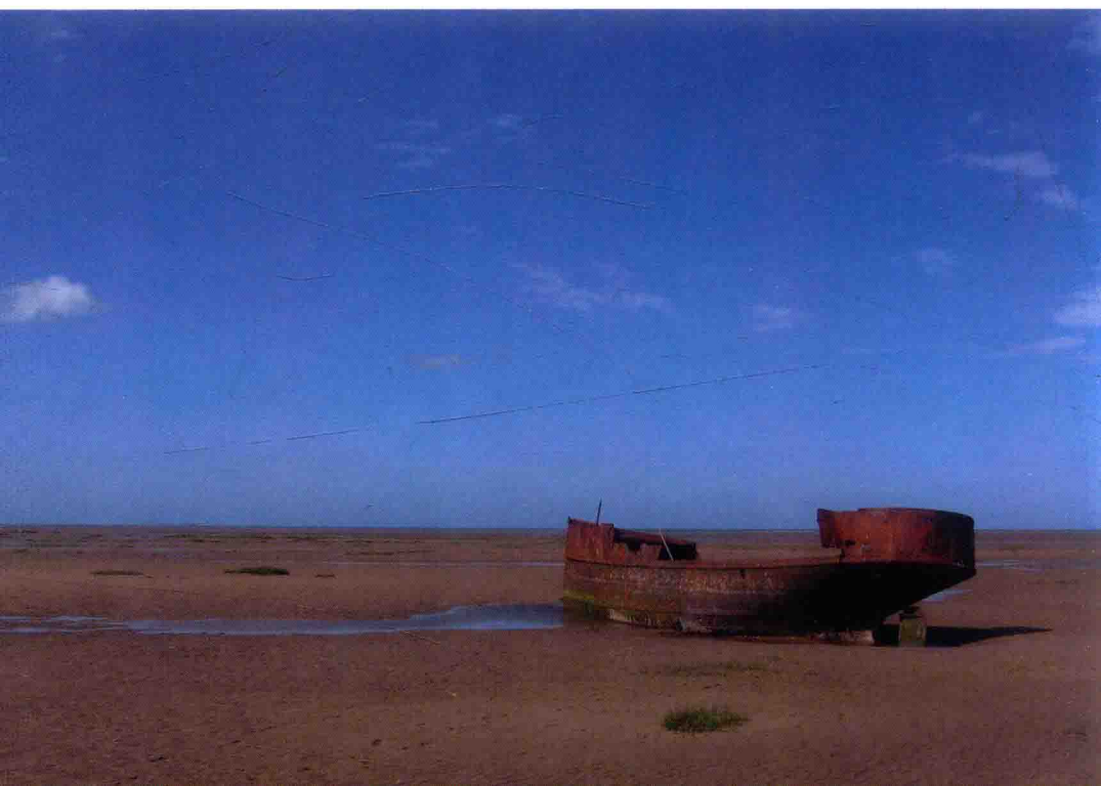
Callum Hill

An Introduction to Sustainable Resource Use



An Introduction to Sustainable Resource Use

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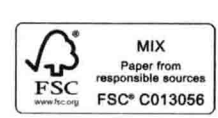

An Introduction to Sustainable Resource Use

Foreword

Humankind's stress on the regional natural resources required for survival has impacted civilizations for centuries, if not millennia. Empires have risen and fallen over control of critical resources. Industrialization has greatly accelerated and globalized these impacts in the last two centuries. No longer does the world have the time or luxury to permit one region's natural resources to recover while another's is plundered. With this globalization has come increased visibility and public awareness of the damage being done. The issues surrounding the sustainable use of resources came to dominate public discourse during the second half of the 20th century. These issues will only increase in importance in the 21st century as people increasingly ask, 'Will we be able to live sustainably on the planet this century, or ever?' However, the path to sustainable use of global resources is not an easy one and there are many blind alleys and pitfalls for the unwary.

An Introduction to Sustainable Resource Use examines the consequences of the way we use materials today and clearly demonstrates that there are no simple answers. The linear throughput model of material use arises from the early days of the industrial revolution when resources seemed inexhaustible and there was little concern expressed for the environment. In recent years we have become more aware of the finite nature of the planetary resources and the ability of the environment to be able to cope with our wastes. Scientists have voiced many warnings in the past. However, as Callum Hill points out in this extremely valuable and interesting text, many dire projections have proved to be overly pessimistic or just plain wrong. But there are limits, and his writings help the reader understand what those limits are and how we might more realistically view sustainable existence.

Human beings have proven to be amply capable of exploiting natural resource supplies while ignoring the finite nature of those resources, thus leading to a misplaced sense of security. Perhaps less well understood, and an issue that Callum Hill thoroughly examines, is that the more pressing limits that we currently face are actually found at the other end of the 'pipe' (i.e. the ability of the planet to deal with the massive volume of wastes that are being dumped in the environment). Is there anything that we can do about this? One suggested approach is to attempt to base economic and industrial materials flows upon those of ecosystems – in a manner similar to that of industrial

ecology. This approach certainly has potential, but is not in itself a panacea. The role of forests and farms in providing materials, fuels and industrial feedstocks in the future is also discussed. The rush to develop biofuels has often led to problems as economic factors rather than sustainable use have sometimes been the driver, and issues such as this are examined in order to provide lessons for the way that we should make a transition to a bio-based economy.

Hill demonstrates that a key issue is that economic activity is strongly coupled to both materials and energy use. No amount of incremental efficiency gains can ever allow us to compensate for the exponential nature of economic growth. Other authors have discussed the treadmill of economic growth in much detail, and thus Hill does not deal with this complex issue in depth. However, he does argue that changing the global economic system is not a realistic goal in the short or even medium term to resolve sustainability issues. Although it is possible for governments to mobilize huge financial resources to meet crises, systemic issues such the slow devastation of natural resources tend to pass beneath the radar. The application of technology to develop new energy systems and new ways of using materials is needed to address the root causes of environmental degradation. These technologies are entirely within our grasp today, but Hill suggests that their adoption will require global philosophical change, regardless of the financial driver for these efforts. Hill makes the point that the future approach must be one of strategic investment in new 'green' technologies, research development and, above all, the education of the next generation of people to facilitate this transition to a new industrial age. A key question Hill raises is whether governments of the world have the vision to provide the necessary resources to meet impending future environmental crises.

This text is an excellent introduction to the complex subject of sustainable resource use. It asks many questions and opens the eyes of the reader to the complicated issues surrounding the subject. It is a critical and insightful analysis of the subject matter, often drawing on historical examples, and encourages the reader to ask questions rather than taking matters at face value. At present, there are far too many claims being made for sustainable processes, or eco-friendly products, often based on very flimsy, if not false, data. This book gives the reader the opportunity to get under the skin of the assumptions that are often made to support such claims. Although written from the point of view of a physical scientist, the book is broad enough and clear enough to be understandable by a much wider readership. It is an excellent first text for this subject and contains a wealth of useful information. The text is also sprinkled with interesting anecdotes reflecting the author's breadth of knowledge and his global perspective, permitting integration of details from diverse fields into larger themes to give the reader a complete understanding of problems and potential solutions to global natural resource use. This book will help to open a broader global discussion on the topic of true sustainability.

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List of Abbreviations

AP	acidification potential
BASF	Badische Anilin- und Soda-Fabrik
BTL	biomass to liquids
CCA	copper/chrome/arsenic
CCF	continuous cover forestry
CCS	carbon capture and storage
CDM	clean development mechanism
CFC	chlorofluorocarbon
CO_2e	carbon dioxide equivalents
CST	crude sulphate turpentine
CTO	crude tall oil
DDT	dichlorodiphenyltrichloroethane
DECC	Department of Energy and Climate Change (UK)
DERV	diesel
DNSC	Defense National Stockpile Center
DP	degree of polymerization
DS	degree of substitution
DSM	De Nederlandse Staatsmijnen
DTO	distilled tall oil
EKC	environmental Kuznets curve
ELV	End of Life Vehicle
ERoEI	energy returned on energy invested
EP	eutrophication potential
ETP	eco toxicity potential
EU ETS	European Union Emissions Trading Scheme
FAME	fatty acid methyl ester
GAI	gross annual increment
Gb	gigabarrels of oil
GDP	gross domestic product

GHG	greenhouse gas
GPP	gross primary production
GRACE	Gravity Recovery and Climate Experiment
GWP	global warming potential
HANPP	human appropriation of net primary production
HTP	human toxicity potential
ICI	Imperial Chemical Industries
IPCC	Intergovernmental Panel on Climate Change
JI	joint implementation (projects)
LCA	life cycle assessment
LCI	life cycle inventory
LCIA	life cycle impact assessment
LISS	low impact silvicultural system
MFA	materials flow analysis
NAI	net annual increment
NASA	National Aeronautics and Space Administration
NFRC	natural-fibre reinforced composite
NO_X	nitrous oxides
NPP	net primary production
ODP	ozone depletion potential
odt	oven-dry tonnes
OECD	Organisation for Economic Co-operation and Development
PHA	poly(hydroxyalkanoate)
PLA	poly(lactic acid)
POCP	photochemical oxidant creation potential
ppm	parts per million
RFF	Resources for the Future
RGGI	Regional Greenhouse Gas Initiative
RoHS	Restriction on the Use of Hazardous Substances
r/p	reserve to production (ratio)
SI	Système Internationale d'Unités
SUV	sports utility vehicle
TBTO	tributyl tin oxide
TCDD	2, 3, 7, 8-tetrachlorodibenzo-p-dioxin
TOFA	tall oil fatty acid
UNEP	United Nations Environment Programme
UN FAO	United Nations Food and Agriculture Organization
US48	the contiguous 48 states of the US
USDA	United States Department of Agriculture
USGS	United States Geological Survey
UV	ultraviolet
WCED	World Commission on the Environment and Development
WEEE	Waste Electronic and Electrical Equipment Directive

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Background

(crisis? what crisis?)

Introduction

This is a book about material resources, why we use them, why we throw them away and how long we might expect to be able to keep on doing this. The way that we use these resources seems to be based upon the premise that they are plentiful, or even inexhaustible, and the way that we seem happy to discard them when they cease to please us relies upon the assumption that, in so doing, we do no lasting harm to the ecological functioning of the planet that supports us. The explosive growth in the production and consumption of materials that has occurred as a result of the Industrial Revolution is inextricably linked to economic growth. It is undeniable that these developments have led to significant advances in the material well-being of many people on the planet, but can we continue with this wasteful behaviour forever, or for fifty, or perhaps only ten more years?

In terms of resources, widespread concerns about the availability of petroleum supplies surfaced in the 1970s, when the oil embargo revealed the dependence of Western nations upon foreign suppliers. As a result of these crises, much attention was devoted to the use of resources and their possible exhaustion. Around this time, a voluminous literature appeared discussing the implications of resource use, population growth, economic growth and sustainability. Then, gradually, the crisis receded. The price of crude oil fell dramatically and the problems seemed to fade away. Recent rises in the prices of fossil fuels and many other resources have brought the whole issue into focus again. Simultaneously we are seeing that our activities are starting to have global consequences, such as the discovery that our use of chlorofluorocarbons in refrigerants and aerosol propellants was destroying the ozone layer that protects us from the sun's harmful ultraviolet radiation (there were many sceptics at first) and now with the effects of anthropogenic activities upon the climate. We are seeing destruction of wilderness and appropriation of biological production on a scale that is unprecedented in the history of humanity. Sustainability is back on the agenda

and in a big way. These issues are no longer just the province of a handful of 'fringe' environmentalists. This is big business.

Everyone is talking about sustainability. Every company has a strategy for dealing with the issues. We are bombarded with information about carbon footprints, recycling, environmental friendliness, biofuels, eco-friendly cars and green consumerism. Scientists everywhere seem to have part of the solution to this problem at their fingertips, but they need a little more money to finalize the research work. There are experts who have no difficulty pronouncing what needs to be done to solve the problems. They may even seek to make a meagre living from such activities, and who could begrudge them that?

Along with the message that we have to do something, there is another option. We can carry on behaving in the same way, but we have to do it 'sustainably' (the 'S' word). The system isn't broken, it just needs a little bit of tinkering around the edges. By all means use retail therapy, but please read the eco-labels. Every manufacturer's and trader's website has the same message – this is how we are saving the environment, don't buy our rivals' products as they are not 'sustainable'. There are commentators who insist that there is no problem at all, that if we are running out of something the market will tell us because the price will go up. Higher prices mean more innovation, or the search for substitutes. We don't even seem to agree on whether global warming is anthropogenic in origin. It's confusing to say the least.

This book is an attempt to try and make sense of it all. It is concerned with finding out whether there is a resource crisis or not and it seeks to determine whether or not it is possible for humanity to live on this planet in a sustainable way. It does not so much seek to provide the simple answers that some of the other books on this subject provide, but it does try to ask the right questions.

Sustainability

The concept of sustainability originates in agricultural and forestry production. A sustainable yield in this context is defined as the maximum amount of a commodity that can be harvested from a piece of land without compromising the ability of that land to provide the same harvest in the future. In terms of agricultural or forestry production, this is an easy concept to understand, although it is not necessarily so easy to quantitatively define where this limit lies.

During the presidency of Teddy Roosevelt in the US, Gifford Pinchot (the founder of the US Forest Service) was a strong advocate of the idea of a sustainable yield of timber. This led to the foundation of the Conservation Movement, with supporters of this approach arguing for the management of forests as tree farms in order to maximize timber production. This approach was opposed by John Muir and others in the Preservationist Movement who were concerned about the disappearance of pristine wilderness. Conservation has come to mean something different from this original idea.

As concerns about the environment began to increase, the United Nations (UN) hosted a conference on the Human Environment in Stockholm in 1972. At the end of this conference, the Stockholm Declaration on the Human Environment

was released, leading to the establishment of the United Nations Environment Programme (UNEP). One of the issues that had been considered at Stockholm was the polarization of concerns regarding the environment between rich and poor countries. Richer nations put concern for the environment high on the agenda, while for the poorer countries the over-riding issue was poverty alleviation. In 1974, the World Council of Churches held a conference on the subject of the use of science and technology for human development, at which they proposed a definition of a sustainable human society and examined what sustainability meant (Dresner, 2008). The key issues were:

- There should be an equitable distribution of physical resources between all the peoples of the planet.
- All people should have the opportunity to participate in social decisions.
- The global capacity to supply food should exceed demand.
- Emissions of pollutants should not exceed the carrying capacities of ecosystems.
- The use of non-renewable resources should never exceed the increase in availability due to technological innovation.
- Human activities should not be negatively influenced by variations in global climate.

These show the necessity for human development and human concerns as an essential component in any definitions of sustainability. Without addressing these human needs, environmental concerns were seen as a luxury. Fritz Schumacher addressed this tension between rich and poor nations in his bestseller *Small is Beautiful* (Schumacher, 1973). In this book, Schumacher pointed out that the development strategies that had been employed in developing countries did little to alleviate the problems of the poor in the countryside and were based upon complex imported technology. He coined the term 'appropriate technology' to describe small-scale development projects where the technologies employed could be understood and controlled by local people.

Economic growth

What about the role of economics in providing for sustainable human development? It has been argued that some economic growth is necessary in order to allow for the development of the poor without creating social turmoil (Pirages, 1977). Economic development should be able to occur in developing countries in order to improve the living conditions of people trapped in poverty, yet simultaneously the wealthy should be able to maintain their standard of living. It is highly unlikely those who already have high standards of living would be willing to sacrifice them. Is it possible to achieve this? There certainly is potential to improve the conditions of developing countries by encouraging better and fairer trading conditions. In 1980, the International Union for the Conservation of Nature and Natural Resources (IUCN) published *The World Conservation Strategy* (IUCN, 1980). This report emphasized the importance of population pressure, poverty, social inequity and trading agreements disadvantageous towards poorer countries, as being primary causes of environmental degradation.

In 1983 the UN set up the World Commission on the Environment and Development (WCED) chaired by the Norwegian Prime Minister Gro Harlem Brundtland. In April 1987 the WCED published the famous document *Our Common Future* (WCED, 1987) which is often referred to as the 'Brundtland Report'. In this publication, the meaning of the term sustainable development was defined as being:

> *development which meets the needs of the present without compromising the ability of future generations to meet their own needs.*

This is a simple and much quoted (and misquoted) definition, which means different things to different people. The published document contained the detail behind this definition to explain what the implications were:

- Environmental limits – these are not absolute limits, but there are limitations on the use of environmental resources due to the present state of technology and social organization and the ability of the biosphere to be able to deal with the wastes generated.
- Poverty – the elimination of poverty is essential to allowing all people to meet their aspirations for a fulfilling life.
- Participation – all of the people of the planet should be able to participate in decision-making at all levels.
- Equity – the way in which the resources of the planet are distributed should ensure that the poorer nations of the planet are able to undergo economic growth in order to improve the living conditions of their people. Those who lead more affluent lifestyles should modify their behaviour in order to ensure that they are living within the planet's ecological means.

All of the above statements indicate that the issue is not so much one of insistence that there should be a fair apportioning of resources between generations (inter-generational equity) but rather, that the problems are here and now and therefore we should be concerned with intra-generational equity. It can also be understood that sustainability is about the environment, economics and society; these are the 'three pillars' of sustainability. It is impossible to have any one without the other two. However, the problem arises as to how it is possible to reconcile the needs of economic development for the poorer countries and economic growth for the rich countries with concerns about environmental limitations. Indeed, many developing countries believe that concerns for environmental protection are a luxury for the rich. It has been argued that the continuing appropriation of disproportionate amounts of the world's resources by the wealthy nations is a factor leading to geopolitical destabilization. A sense of injustice, arising from the way that planetary wealth is distributed among the people of the planet, has been cited as one factor (among many) contributing to global terrorism (Richardson, 2006). The Brundtland Report is largely supportive of economic growth and points out that in order to allow the poor and rich countries to achieve some sort of parity it would be necessary to expand the world economy by a factor of 5 to 10. Since this is deemed to be impossible given the resource and environmental limitations, the report insists that these growth

requirements will have to be met by efficiency improvements. This leads us on to the Factor 10 arguments to be discussed later.

Sustainability and capital

Capital is usually associated with money in most people's minds, but there are other ways of viewing capital. For the purposes of understanding sustainability it is useful to define least four types of capital. These are:

- Human-created capital – this is what we make, e.g. buildings, machines and infrastructure.
- Natural capital – air, water, soils, forests, natural resources like oil and minerals, ecosystem functioning, etc.
- Human capital – investment in health, education, nutrition, etc.
- Social capital – the institutions and culture that make a society function.

The way that sustainability is defined looks at how these four types of capital are managed. Crucial to this process is the degree to which one allows substitution between these different types of capital. This gives rise to the concepts of weak, sensible, strong and absurdly strong sustainability (Serageldin et al, 1994).

With weak sustainability, the total amount of capital remains the same, but no importance is placed on the composition of that capital. The assumption is that all forms of capital can substitute for one another equally. Sensible sustainability requires that in addition to maintaining the total capital stock, that the composition of the capital is important. Consequently, it is necessary to define thresholds below which a capital stock could not fall. The problem, of course, is in defining where these critical limits lie. Strong sustainability requires that each of the capital assets should be kept intact. Loss of forest in one area should be compensated for by increasing forest area elsewhere. Profits from exploiting oil resources should be used to develop renewable energy technologies. This view assumes that natural and human-made capital cannot be substituted for one another. Finally, absurdly strong sustainability assumes that non-renewable resources could not be used at all, or at a rate no greater than their geological replenishment rates. Renewable resources can only be used at a rate that does not compromise future productivity.

Population growth and resources

Concerns regarding the optimum population of humans that can be supported by the land stretch back to antiquity. Aristotle was of the opinion that the ideal nation state should keep the size of its population in accord with that of its land. One of the most famous works concerning the consequences of populations outstripping their resources is *An Essay on the Principle of Population* (1798) by the Reverend Thomas Robert Malthus (1766–1834). The essence of Malthus's argument was that human