

*Commentary*

## Wrapping Our Brains around Sustainability

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**Abstract:** As many of us begin to embrace the concept of sustainability, we realize that it is not simply something that we ‘do.’ Rather, sustainability is a destination that we aspire to reach with the selection of the sustainable pathways that we choose as we proceed along the journey. We are embarking on a new journey with the creation of *Sustainability*, an on-line, open access journal. As stated on the journal’s website, *Sustainability* is an international and cross-disciplinary scholarly journal of environmental, cultural, economic and social sustainability of human beings, which provides an advanced forum for studies that are related to sustainability and sustainable development. To genuinely wrap our brains around the impact that our actions have on the sustainability of our planet, we must first understand something of the big picture and have a firm grasp of the terminology. To help further clarify the elusive term ‘sustainability,’ without attempting to provide an exact definition, this paper outlines various, inter-related concepts and basic practices and approaches that are being used in the name of sustainability, including: traditional end-of-pipe control strategies, life cycle, environmental sustainability, urban sustainability, industrial ecology, business sustainability, sustainable supply chain systems, sustainability indicators and metrics, green chemistry and green engineering, design for the environment, sustainable buildings, eco-tourism, and renewable and sustainable energy and fuels.

**Keywords:** Sustainability, sustainable development, life cycle, industrial ecology, supply chain, green chemistry, green engineering, design for the environment, eco-tourism, energy.

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A combination of forces, including a growing world population along with rapidly expanding consumption, is causing a significant stress on the earth’s resources and compromising its ability to maintain human health and environmental quality. The challenge for this and future generations is to

prevent or mitigate the negative consequences that can come with this growth while also allowing for continual improvement in human health protection and environmental quality, as well as our overall standard of living. These increasing demands on our environment require us to adopt a new set of approaches in order to move toward a sustainable future.

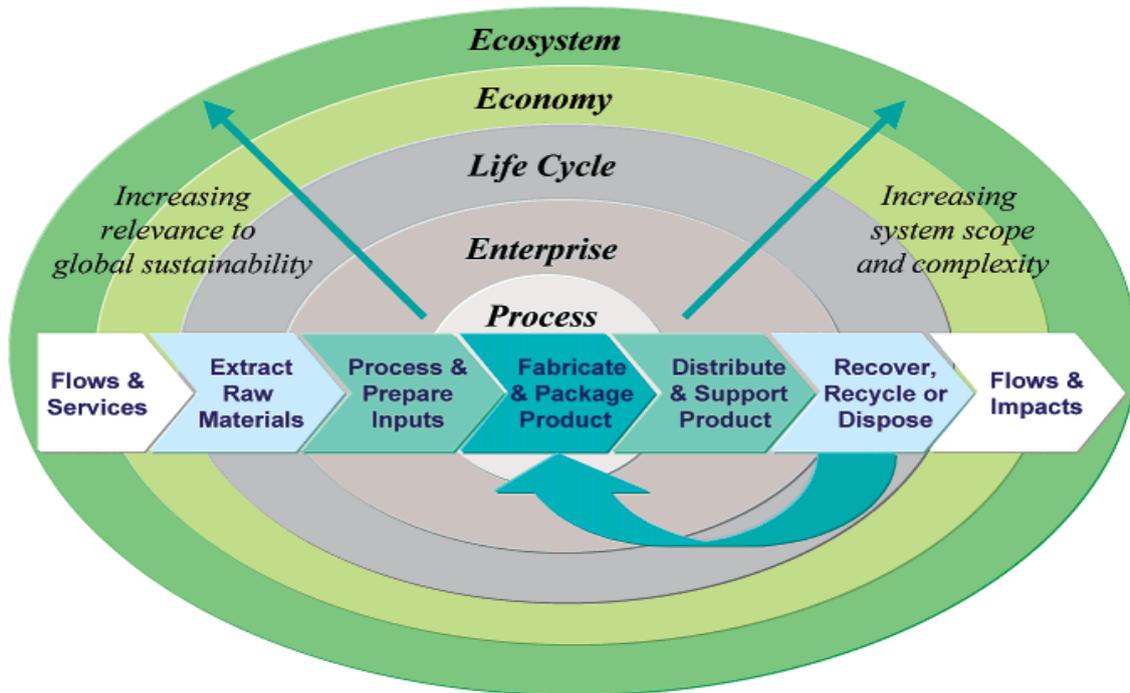
We are embarking on a new journey with the creation of *Sustainability*, an on-line, open access journal. As many of us begin to embrace the concept of sustainability, we realize that it is not simply something that we ‘do.’ Rather, sustainability is a destination that we aspire to reach with the selection of the sustainable pathways that we choose as we proceed along the journey. As stated on the journal’s website (<http://www.mdpi.com/journal/sustainability>) *Sustainability* is an international and cross-disciplinary scholarly journal of environmental, cultural, economic and social sustainability of human beings, which provides an advanced forum for studies that are related to sustainability and sustainable development. In other words, the journal covers a very broad range of topics, yet the focus is on identifying sustainable practices while challenging conventional thinking and stepping outside accepted paradigms that are found in the private and public sectors.

We live on a planet where practically all things and all people are unavoidably connected. With six billion people roaming the globe, our actions at home and at work affect other communities globally. To genuinely wrap our brains around the impact that our actions have on the sustainability of our planet, we must first understand something of the big picture and have a firm grasp of the terminology. Without attempting to provide an exact definition, I outline below various, inter-related concepts and basic practices and approaches that are being used in the name of sustainability. This list is far from complete, but it is intended to help to further clarify the elusive term ‘sustainability.’

### **Transitioning from Traditional Strategies**

Traditional end-of-pipe control strategies have historically focused on mitigating pollutant emissions and have served us well in providing cleaner air, water, and land. Strategies for the proper management of toxic chemicals and hazardous and radioactive wastes and materials are an important part of a sustainable environment. These strategies will continue to be important in a sustainable future.

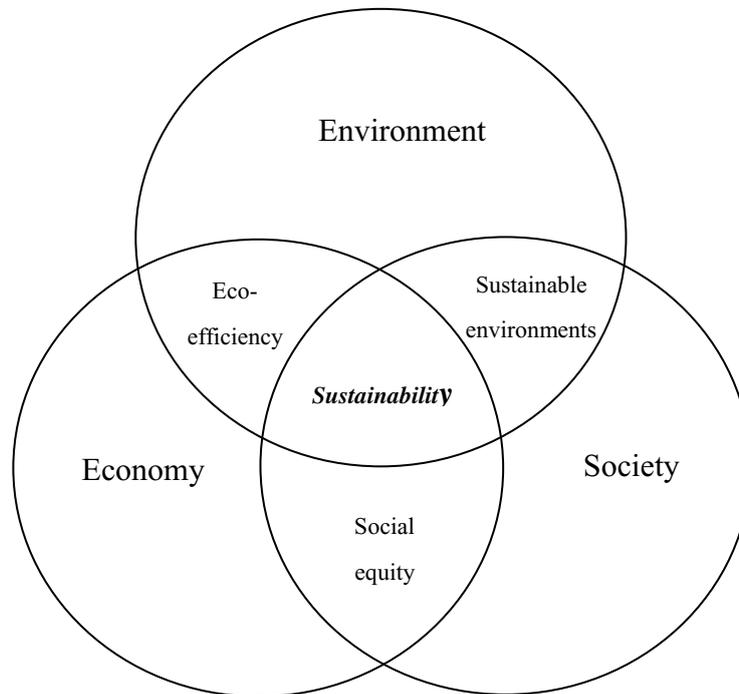
Many of the environmental protection strategies that we have become accustomed to can be viewed as short-term, or quasi-environmental fixes. We now understand that environmental problems are rarely contained within a single resource area or within a single product’s life cycle. Instead, they require longer term strategies that extend across geographic regions and timeframes. It has become obvious that a more integrated, systems-based approach is required to meet the needs of today while maintaining the prospects for the same quality of life for tomorrow’s generation. Bakshi and Fiksel (2003) created a useful diagram (Figure 1) which depicts the challenge of expanding our focus from process to ecosystem and incorporating the life cycle view in our ‘quest for sustainability.’

**Figure 1.** Expanding the boundaries of sustainability [1].

### As the Challenges Grow More Complex, the Solutions Become Fuzzier

Since the World Commission on Environment and Development issued its 1987 report, *Our Common Future*, the term “sustainability” has managed to become both a rallying cry as well as point of controversy. By the time of the 1992 United Nations Conference on Environment and Development (the “Rio Earth Summit”), there was a growing consensus that the concept of sustainability should encompass interrelated ideas drawn from economic, social, and environmental realms (also shown at times as “profit, people, and planet”). The interrelated nature of these three domains has been referred to as the “three pillars of sustainability.” The goal of sustainability, then, relates to the interconnectedness of economic, social, institutional, and environmental aspects of society and ecology. It is commonly depicted as the intersection of three intertwined circles (see Figure 2).

**Figure 2.** Sustainable practices (at the intersection) allow for satisfactory outcomes for humans and the environment while fulfilling the social and economic needs of current and future generations.



Sustainability requires the consideration of the economic, environmental and social aspects of products and product systems [2]. Therefore, responsible decision-making in public policy, industry and related fields should consider those issues for present and future relevance. Specialists in each field best deal with their particular area of expertise. For example, social scientists are well acquainted with social sustainability; economists deal with economic sustainability, while environmental scientists and engineers deal with environmental sustainability. We need to find an effective way to bring these disciplines together. Currently there is no single program or technique that is capable of delivering an overall answer with regard to environmental decision-making. Further research in this area is needed to develop a viable decision-support framework.

There is a growing recognition that the challenges our planet is facing are becoming increasingly complex and fuzzy. As environmental awareness increases, industries and businesses have responded by providing “greener” products and using “greener” processes. Many companies have found it advantageous to explore ways of moving beyond compliance by using pollution prevention/cleaner production strategies and environmental management systems to improve their environmental performance. The evolution of environmental strategies over the years has moved from a single-medium, regulatory strategy to one that aims for sustainability across all media for the short and long-term. In this movement, environmental managers have begun to realize the need to look holistically at the impacts of products and processes from cradle-to-grave (or cradle-to-cradle, as it is sometimes called).

## **Environmental Sustainability**

The sustainability paradigm tends to have mainly an environmental-focus that is derived primarily from an ecological or environmental science perspective. The objective of environmental sustainability is to maintain ecosystem health and integrity. Through models and measurement, researchers aim to understand vulnerability and resilience in ecological systems as affected by external stressors (e.g. climate change, land use patterns, pollution, and invasive species). Indicators of ecological health are also developed, measured, and tracked to support ecological sustainability.

The *preservation of ecosystems* and concomitant reduced risks to human well-being is paramount in environmental sustainability. In line with this strategy is the promotion of sustainable use of land and of water; and the protection of species and biodiversity.

## **Urban Sustainability**

Urban planning (including transportation and infrastructure) for optimization of land use, material use, and energy use is a key component of this facet of sustainability. Also important are studies in community-based decision-making and development and tracking of community-based social, economic, ecological and human health indicators. The environmental and urban ecology perspectives intersect where environmental protection methods can be applied to urban ecosystems. Other considerations in urban sustainability include: controlled population growth and urbanization; effective use of green spaces in urban environments; sustainable patterns of production and consumption among growing demands; and resource conservation (including marine-based resources) and post-consumer recycling.

## **Industrial Ecology**

Industrial Ecology is derived heavily from an engineering perspective, with a focus on functional design and material selection for products and production systems. The objective is to maximize energy and material use efficiency and, in addition, to minimize potential environmental impact over multiple product life cycles. Also important from this perspective are analyses and optimizations of regional, national, and international webs of material flows.

## **Business Sustainability**

The approach for business sustainability mainly advocates consideration of economics, ecology, and equity in decisions made in a business context. While the focus is on efficient lean operations that save materials, energy, and money, care must be taken to ensure that the focus is not only on financial sustainability from an operations standpoint. In the broader context of general business, corporate social responsibility (CSR) is a growing concept. It frequently is indistinguishable from similar concepts such as corporate sustainable development, corporate responsibility, and corporate

citizenship. Some people believe CSR to be the private sector's way of integrating the environmental, economic, and social imperatives of their activities, resembling the concept of the triple bottom line.

Increasing demands for change are causing significant adjustments in how companies design, produce and deliver products and services to their customers. It is hoped, perhaps demanded, that the economy of this evolving century will be characterized by a decrease in the material and energy content of products and an increase in their knowledge content. The challenge for businesses and governments will be to ensure that continued economic development is ecologically and socially sustainable. With the need and desire for equal development opportunities for all, the issue of sustainability continues to be a key issue as we move forward. We are beginning to recognize that the path towards sustainability requires life cycle thinking and the cooperation among the various stakeholders throughout the life cycles of products and services. Many senior executives around the world express a need to better incorporate a meaningful measure of corporate contributions to sustainability, to learn how they can do better, and to change the approaches they have applied in the past.

### **Sustainable Supply Chain Systems**

Products such as automobiles and computers, which involve a series of discrete manufacturing and assembly processes along the supply chain, can generate a significant ecological footprint in terms of material, energy, and land use as well as industrial wastes and emissions. Manufacturers have used a variety of design techniques to reduce the resource intensity of their manufacturing and logistical systems. These techniques include simplifying product architecture to reduce the number of distinct parts and assembly operations (which also enables easier maintenance and disassembly); utilizing recycled materials or refurbished components; avoiding substances with undesirable properties such as carcinogenicity, toxicity, flammability, ozone depletion, or environmental persistence; reducing electrical and thermal energy use through process modifications or transportation efficiency (e.g., improved product geometry for pallet loading); utilizing quality improvement and "lean" manufacturing techniques (e.g., just-in-time inventory replenishment) to reduce work-in-process and scrap; and collaborating with customers and suppliers to streamline the supply chain and minimize waste.

### **International and National Policies**

There is a common paradigm derived from international policy and development. The business climate of the 21st century continues to see increases in globalization, advancements in information technology, rapid process and product innovations and chaotic marketplace demands. Therefore, the focus of this paradigm is on political and developmental differences among nations and associated implications for potential large-scale environmental problems, such as global climate change, resource degradation, ocean systems degradation, and global transport of pollutants. The effects of war, trade, and trade agreements on the environment are also important. All this is taking place on a planet that is quickly approaching its ecological limits. Signs are already being seen in critical areas, such as ozone layer depletion, global climate warming and various types of environmentally induced toxic pollution.

Of course, in tending to the needs of society, governments play a vital role in the development, implementation and monitoring of sustainable national policies which support national and international treaties for sustainable development. Areas in which government direction is needed include: changing consumption and production patterns; appreciation for cultural diversity and traditions, development of healthy social systems; and widespread education and awareness of sustainability.

### **Sustainability Indicators and Metrics**

The lack of quantified measures of sustainability leaves investors, analysts, and non-governmental organizations (NGOs) unsure of a corporation's status with regard to its written commitment to corporate environmental and social responsibility. One potential approach is a mathematically robust process to quantify this subjectivity in a way that is technically sound and legally defensible. Recent heightened concerns regarding global climate change has led to a distinct emphasis on measuring greenhouse gas emissions. However, a comprehensive set of metrics is needed in order to include all aspects of human health and environmental protection.

### **Sustainable Process Systems**

For many, sustainability translates into environmentally friendly processes, products, and services. The synergy between process performance and sustainability is well captured in the concept of eco-efficiency, which measures the value produced as output per unit of resource input. Reductions in labor intensity, energy consumption, process hazards, and waste generation tend to translate into lower capital requirements, lower economic risks, and lower operating and maintenance costs. New technologies such as process intensification and microreactors have demonstrated the potential for order of magnitude increases in process yield and capital productivity. At the same time, significant advances have occurred in the fields of green chemistry and green engineering, also known as sustainable chemistry and sustainable engineering, which seek new pathways and catalysts for environmentally benign chemical synthesis and processing.

### **Design for the Environment**

DfE is a general concept that refers to improving the design of an existing or developing product by identifying where impacts across the product's life cycle can be minimized. Sustainable use of resources such as land, water, atmosphere and other biological resources are key factors. Reductions in energy demand, use of toxic materials, and pollutant emissions and waste as well as increased opportunities for recycling are also important aspects of DfE. To support design for recyclability, design for disassembly needs to be addressed. Design for disassembly enhances maintainability or serviceability of a product, and it enables recycling of materials, component parts, assemblies, and modules.

## **Sustainable Building Systems**

Many architects and engineers have embraced the concept of green buildings. Example practices include energy efficiency, use of local materials, respect for natural surroundings, utilization of ecological services (e.g., heating and cooling), and sensitivity to human well-being, especially concerning indoor air quality. Apart from the obvious energy and environmental benefits, studies suggest that sustainable buildings also improve employee satisfaction and productivity.

## **Sustainable Tourism (Eco-Tourism)**

Many countries reap significant economic benefits from tourism, but often these activities occur to the detriment of the environment. Eco-tourism has become a popular buzz word as vacation goers explore nature. However, the practice of eco-tourism must go beyond being used merely to promote tourism and an attempt toward the commercialization of tourism schemes that are disguised as environmentally-friendly. Eco-tourism practices should protect our natural surroundings as well as educate people about the beauty and fragility of nature.

## **Renewable and Sustainable Energy and Fuels**

Developing renewable and sustainable energy and fuels is paramount. Today, even the most efficient, renewable energy source, beyond the local scale, requires inputs from fossil-based energy. Without truly sustainable energy, all the actions we take will be only short-term solutions that do not fix the long-term consequences. Moving towards energy sustainability will require changes not only in the way energy is supplied, but in the way it is used and the demands we place on it.

## **Are We There Yet?**

How long will this journey to sustainability take? We may never know. However, it will be an important, challenging, and rewarding journey, as we dedicate ourselves to ensuring that our children and our children's children have adequate natural resources in which to grow and thrive. The material and information that will be presented in this journal will help us wrap our brains around issues that have such long-term consequences, such as global climate change. Through the sharing of information we will move beyond ill-founded claims of sustainability to identify concrete actions and practices that do in fact reduce our consumption of natural resources and protect human health and the environment as we continue on our journey.

I invite you to join me and the editorial and managing staff of *Sustainability* as we take these first steps toward a sustainable future.

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