THESAURUS OF SUSTAINABILITY

Richard S. Levine, Michael T. Hughes, and Casey Ryan Mather
Center for Sustainable Cities, University of Kentucky

Thesaurus – Latin for “treasure house,” provides speakers, writers, and thinkers with the perfect word to fit the occasion

Sustain – to cause to continue (as in existence or a certain state, or in force or intensity); to keep up, especially without interruption, diminution, flagging, etc.; to prolong.”[1]
- Webster's New International Dictionary

PREFACE

Sustainability is an emerging paradigm which must become the dominant worldview if anything approaching the Western standard of living is to persist into the future. Because countless approaches to the question of sustainability emerging in numerous sectors and disciplines in different cultures, countries and climates currently exist, definitions and streams of research and application abound. To date no recognized practice or common language in the sustainability movement has gained hegemony and consequently, no commonly accepted operational definition. It should be no surprise then, that the term sustainability is used (and almost universally misused) to mean a wide variety of often inconsistent and contradictory practices. In attempting to craft a Thesaurus of Sustainability, the current authors cannot claim this resulting document to be exhaustive, comprehensive, or, much less, unbiased.

Two main contributions to the sustainability discussion are offered by the authors. One is that terms such as sustainable architecture, sustainable agriculture, and sustainable economics should be replaced by Sustainability Oriented Architecture, Sustainability Oriented Agriculture, and Sustainability Oriented Economics. With the use of this new term, "Sustainability Oriented," a distinction is made between tools for sustainability, or practices that could become part of the larger process of sustainability, and a comprehensive civil society sustainable city-region process. Armed with this distinction, it is clear that the term sustainability, in common as well as professional use, almost always refers to sustainability oriented practices not the comprehensive practice of sustainability itself.

The authors' second contribution is an operational definition of sustainability – the only operational definition we have been able to identify in all the discourse on the subject to date. The criteria or characteristics of sustainability are present in all well known descriptions and definitions; however, what they lack is an accounting of how to get there from here, or how to design and manage the emerging sustainable city in dynamic and through-going way. Such an operational definition of sustainability will be presented as the culmination of this Thesaurus. On the surface this operational definition would seem to be making a claim upon the spaces of the many other approaches to sustainability that this Thesaurus attempts to cover. Instead, the authors attempt to typify these individual approaches as potentially valuable tools for pursuing sustainability processes, but necessarily within the larger integrative operational definition.

Even in the SUCCESS project, whose very structure was aimed at maximizing integration, manifested a tendency toward disciplinary isolation that hindered the pursuit of a synergistic collaboration toward sustainability. In these early years of the study of sustainability, many researchers have in fact developed their own operational definitions that are strictly contained within their disciplinary boundaries. Thus, sustainable agriculture, sustained yield forestry and (much to the dismay of the current authors) sustainable architecture, have emerged as practices that are not much concerned with interfacing either with other disciplines or with the larger question or practice of sustainability. The positive side of this is that many different disciplines have developed excellent Sustainability Oriented Tools that are useful within their own disciplines and may well become useful in larger interdisciplinary, civil society processes. The negative side of this is that specialists are often much more comfortable employing their Sustainability Oriented Tools within their own disciplines than they are in working with other disciplines, or indeed with the actual citizen stakeholders who should be the focus of any eventual sustainability process.

This dynamic unfolded within the SUCCESS project in sometimes frustrating, but always interesting ways. Three sorts of actors emerged. The physical scientists, in their relentless pursuit of data, calculations and applicable theory, for the creation of coherent models of resource, material, energy and sometimes economic flows, had a deep distrust of the social scientists whose loose, abstract, qualitative, and sometimes touchy-feely methods did not look to them as very scientific. Then there were the social scientists, who were developing all sorts of often innovative methods for teasing out the needs, desires, feelings, and problems of the local villagers in attempts to establish new civil society processes focusing upon the questions of "what to change" in the villages and "what to maintain." The social scientists were perhaps more open to the work of the physical scientists than vice-versa, but they were deeply suspicious of the latter's methods, which appeared to omit any real consideration for the local culture, traditions, and aspirations of the villagers. Indeed it sometimes seemed that cultural considerations might well be a hindrance to the application of any scientific recommendations. Still, the role of social and cultural considerations in the pursuit of sustainability has been frequently marginalized in the pursuit of the scientific, technical and economic aspects of sustainability practice. Such oversight "misses the forest for the trees," as the practice of sustainability, whatever else it may also be, is primarily the pursuit of a way of life in a local place and a local culture within the limits of nature. It needs to be acknowledged that a community of people negotiating how they will choose to live within their fair share of the earth's resources, assisted by technical means, will be the basis of the future sustainable city-region.

Finally, the third set of actors were the villagers themselves operating through the local, so-called, “critical reference group.” This group was in many ways the liaison between the villagers and their culture, and the research team. The establishment of these groups represented the hope of anchoring civil society processes within the villages. But as this form of local democracy was, in effect, a new and somewhat alien institution to the local culture, it was never clear how representative, how effective, or how empowered these teams of villagers could become.

The Thesaurus that follows, then, is neither comprehensive nor unbiased. Rather, it is, first of all, an attempt to present an overview of the current state of sustainability practice as it exists largely in the West. Secondly, it serves as an immanent critique of those practices, often drawing upon the obscure meanings and unrealized possibilities of clusters of concepts organized around the core term, sustainability. Finally, it strives to offer a comprehensive alternative through which the sustainable city-region may be realized. Along the way, it challenges conventional ways of thinking and opens up a window onto fields of inquiry and pathways of social action that in concert provide the best hope for affecting that paradigm shift so essential if the twenty-first century is to be the Age of Sustainability.

INTRODUCTION

This Thesaurus is a collection of terms and concepts that survey the broad discourse on sustainability. Most definitions of sustainability, and the various disciplinary attempts to put it into practice, are not well suited in and of themselves for the actual achievement of sustainability. These definitions are descriptive of a future state of sustainability but lack a prescriptive process that presents how the transition from the present state of unsustainability to a future sustainability process may occur. The first section of this Thesaurus presents various attempts at defining sustainability. These abstract definitions have provided just enough information to inspire many different and often times conflicting attempts of reducing the level of unsustainability, which are categorized in the second section of this Thesaurus. Recently, social constructivists have entered the fray and have deemed sustainability "an essentially contested concept," because of the many diverse approaches to the subject. The third section of this Thesaurus explores this debate and offers a way out of the unworkable conundrum in which social constructivist analysis places sustainability. Finally, the fourth section presents a definition of sustainability that describes an operational process through which sustainability may be achieved in practice. The information in this Thesaurus is no way exhaustive, but it largely represents the major issues and approaches of the sustainability debate. This document seeks to clarify the language surrounding sustainability, place current approaches in what the authors interpret as their proper contexts, and present a process that integrates scientific disciplines and local stakeholder participation into an ongoing balance-seeking process well suited to the achievement of sustainable city-regions. The Thesaurus is organized so that by reading the chapter headings as a first pass the reader will get a sense of the more detailed content within.

1. ABSTRACT DEFINITIONS OF SUSTAINABILITY (DESCRIPTIVE)

The definitions of sustainability and sustainable development presented in this section are abstract in nature. The most popular of these, offered by the Brundtland Commission has defined sustainable development as "meeting the needs of the present generation without compromising the ability of future generations to meet their needs."[2] This definition has created an awareness that can serve as an inspiration to a growing number of academicians, politicians and activists who are becoming aware of the harmful ecological consequences of the prevailing economic, societal, and urban patterns of modern life. The Brundtland definition and others mentioned in this section have inspired many hundreds of communities around the world to adopt broadly based and loosely organized programs and varying sets of checklists that are meant to guide these cities on a path toward sustainability. However, a shortcoming of such approaches, is that by following them a community may become quantitatively less unsustainable in its details, which (it is argued below) is not the same as operating through sustainability processes. The definitions presented in this section, at best, describe some of the attributes likely to be found in an eventual sustainable society but do not present an operational process necessary for bridging the gap between the unsustainable present and a sustainable future. Toward the end of this section are attempts at creating comprehensive, multidisciplinary approaches to sustainability; some even mentioning a systems approach that could unite compartmentalized professions. However, these are still lacking a comprehensive way to create an operational method to generate sustainable cities.

1.1 INTERGENERATIONAL EQUITY

"Sustainable Development is meeting the needs of the present generation without compromising the ability of future generations to meet their needs."[3]
- Gro Harlem Brundtland, The World Commission on Environment and Development, (1987)

"Our Creator made the Earth for the use of the living… that one generation of men cannot foreclose or burthen its use to another… We may consider each generation as a distinct nation, with a right… to bind themselves, but none to bind the succeeding generation, more than the inhabitants of another country."[4]
–Thomas Jefferson

"Then I say the earth belongs to each . . . generation during its course, fully and in its own right, no generation can contract debts greater than may be paid during the course of its own existence."[5]
- Thomas Jefferson (1789)

"Sustainability refers to a very old and very simple concept—the ability to keep going over the long haul. Think of it as extending The Golden Rule through time, so that you do unto future generations that which you would have them do unto you."[6]
- Robert Gilman

"In a free adaptation of Kant's categorical imperative, a society can only be called sustainable when the maxims underlying its behavior could in principle also serve all others."[7]
- Wolfgang Sachs, et al. (1998)

"Sustainability is equity extended into the future." [8]
- Herman E. Daly

1.2 ECOLOGICAL ASPECTS

"A thing is right when it tends to preserve the integrity, stability, and beauty of the biotic community; it is wrong when it does otherwise."[9]
- Aldo Leopold (1966)

"In a sustainable community, resource consumption is balanced by resources assimilated by the ecosystem. The sustainability of a community is largely determined by the web of resources providing its food, fiber, water, and energy needs and by the ability of natural systems to process its wastes. A community is unsustainable if it consumes resources faster than they can be renewed, produces more wastes than natural systems can process or relies upon distant sources for its basic needs."[10]
- Sustainable Community Roundtable Report

"[Sustainability] Output Rule:
Waste emissions should be within the assimilative capacity of the environment to absorb without unacceptable degradation of its future waste-absorptive capacity or other important services.
[Sustainability] Input Rules:
a) Renewables: harvest rates of renewable resources should be within the regenerative capacity of the ecosystem.
b) Non-renewables: depletion rates should be equal to the rate at which renewable substitutes can be developed and deployed."[11]
- Herman E Daly (1998)

"'Sustainable Development' requires simultaneous and sustainable use of all resources…If 'Sustainable Development' is to be achieved and justice is to be meted out to the future generation then the following steps are to be taken up:
1. The paradigm of 'strong substitutability' has to be replaced by that of 'weak substitutability'.
2. The anthropocentric models of development are to be discarded and eco-centric models that take care of all natural resources both living and non-living, including homo sapiens, that is, the entire ecosystem, are to be evolved."
3. To ensure intergenerational equity, steps are necessary to be taken to ensure intra-generational equity as well."[12]
- Milindo Chakrabarti

1.3 ECOLOGICAL AND SOCIAL ASPECTS

"Sustainability is more a symbol than a scientific concept. It's the focus for a new debate about the shape of the future, a signpost pointing to a general direction that we must take while the debate is engaged about the best path forward. Commitment to human and societal well-being is as important as ecological commitment to the planet. We must preserve a planet fit to live on and also create organizations that sustain the quality of our social life."[13]
- Dexter Dunphy (2002)

"[A sustainable society is a] society whose long term prospect for continuing to exist are good. Such a society would be characterized by an emphasis on preserving the environment, developing strong peaceful relationships between people and nations, and an emphasis on equitable distribution of wealth."[14]
- Coop America Quarterly (1995)

"[Sustainability is] Improving the quality of human life while living within the carrying capacity of supporting eco-systems."[15]
- The World Conservation Union (IUCN), United Nations Environment Programme (UNEP), and World Wide Fund for Nature (1991)

"In its broadest scope, sustainability refers to the ability of a society, ecosystem, or any such on-going system to continue functioning into the indefinite future without being forced into decline through the exhaustion or overloading of key resources on which that system depends. In the case of society, those resources might be material, such as fuels or topsoil; they might be social, such as educational levels or the sense of fair play; or they might be waste-absorbing natural systems, such as wetlands or the atmosphere." [16]
- Robert Gilman (1992)

1.4 ECOLOGICAL AND ECONOMIC ASPECTS

"Sustainability is a relationship between dynamic human economic systems and larger, dynamic, but normally slower changing ecological systems, such that human life can continue indefinitely, human individuals can flourish, and human cultures can develop—but also a relationship in which the effects of human activities remain within bounds so as not to destroy the health and integrity of self-organizing systems that provide the environmental context for these activities." [17]
- B.G. Norton (1992)

"Living within one's true income, living sustainably, means living off only your fair share of the interest rather than the principal— of nature's services and resources. It is being able to answer 'yes' to the question, 'Could all 6 billion people on this planet do as I do (or as my organization does) without permanently reducing our natural capital?'" [18]
- Paul Lipke

"Sustainability is the [emerging] doctrine that economic growth and development must take place, and be maintained over time, within the limits set by ecology in the broadest sense - by the interrelations of human beings and their works, the biosphere and the physical and chemical laws that govern it . . . It follows that environmental protection and economic development are complementary rather than antagonistic processes."[19]
- William D. Ruckelshaus (1989)

"Sustainability is an economic state where the demands placed upon the environment by people and commerce can be met without reducing the capacity of the environment to provide for future generations. It can also be expressed in the simple terms of an economic golden rule for the restorative economy: Leave the world better than you found it, take no more than you need, try not to harm life or the environment, make amends if you do."[20]
- Paul Hawken (1993)

"Sustainable development…necessarily means a radical shift from a growth economy, and all it entails, to a steady-state economy, certainly in the North, and eventually in the South as well."[21]
- Herman E. Daly (1996)

"[Sustainability (as exemplified in the Steady-State Economy) is] an economy with constant stocks of people and artifacts, maintained at some desired, sufficient levels by low rates of maintenance 'throughput', that is, by the lowest feasible flows of matter and energy from the first stage of production ... to the last stage of consumption ... It should be continually remembered that the SSE is a physical concept."[22]
- Herman E Daly (1977)

"In a sustainable society, nature is not subject to systematically increasing:

1. concentrations of substances extracted from the earth's crust;
2. concentrations of substances produced by society;
3. degradation by physical means
   and, in that society. . .
4. human needs are met worldwide."[23]

- The Natural Step

1.5 SOCIAL AND PLACE-BASED ASPECTS

"The word sustainable has roots in the Latin subtenir, meaning 'to hold up' or 'to support from below.' A community must be supported from below - by its inhabitants, present and future. Certain places, through the peculiar combination of physical, cultural, and, perhaps, spiritual characteristics, inspire people to care for their community. These are the places where sustainability has the best chance of taking hold."[24]
- Muscoe Martin (1995)

1.6 ECOLOGICAL, SOCIAL, AND ECONOMICAL ASPECTS

“Sustainable development is a process of simultaneously ensuring continuation of the economic, social and ecological basis of human life.” [25]
— Sharachchandra Lélé (1991)

Sustainable development involves the simultaneous pursuit of economic prosperity, environmental quality and social equity. Companies aiming for sustainability need to perform not against a single, financial bottom line but against the triple bottom line. [26]
-World Business Council on Sustainable Development

“Sustainable development or sustainability involves three broad interacting realms: environment, economics, and social equity. These three realms could be called the ecological imperative, the social imperative, and the economic imperative. It has been said that ‘These three aspects are inseparable and our ability to develop a deeper understanding of this linkage is critical to our prospects for sustainability’”[27]
- John Robinson and Caroline Van Bers (1996)

1.7 ECOLOGICAL, SOCIAL, ECONOMIC, AND POLITICAL ASPECTS

"As our attention has been focused on conflict, on globalization, or most recently on terrorism, we have often failed to see how these are connected to the issue of sustainability. That word has become a pious invocation, rather than the urgent call to concrete action that it should be. Sustainable development may be the new conventional wisdom, but many people have still not grasped its meaning. It is a life-or-death issue for millions upon millions of people, and potentially the whole human race. Far from being a burden, sustainable development is an exceptional opportunity: economically, to build markets and create jobs; socially, to bring people in from the margins; and politically, to reduce tensions over resources that could lead to violence and to give every man and woman a voice, and a choice, in deciding their own future."[28]
- Kofi Annan (2002)

1.8 SYSTEMIC ASPECTS

“A sustainable society is one that persists over generations, one that is far-seeing enough, flexible enough, and wise enough not to undermine either its physical or its social systems of support…From a systems point of view, a sustainable society is one that has in place informational, social, and institutional mechanisms to keep in check the positive feedback loops that cause exponential population and capital growth…in order to be socially sustainable the combination of population, capital, and technology in the society would have to be configured so that the material living standard is adequate and secure for everyone.”[29]
- Donella H. Meadows, Dennis L. and Jørgen Randers (1992)

"The focus and scale of sustainability efforts depend on local conditions, including resources, politics, individual actions, and the unique features of the community. The sustainable communities approach has been applied to issues as varied as urban sprawl, inner-city and brownfield redevelopment, economic development and growth, ecosystem management, agriculture, biodiversity, green buildings, energy conservation, watershed management, and pollution prevention. Many of these issues and other community problems cannot easily be addressed by traditional approaches or traditional elements within our society. Many people feel it is better to address such problems through a more collaborative and holistic systems approach because such problems are diffuse, multidisciplinary, multiagency, multistakeholder and multisector in nature."[30]
- Lachman, Beth E.

2. TOOLS FOR THE IMPLEMENTATION OF SUSTAINABILITY: SUSTAINABILITY ORIENTED MEANS

There seems to be an underlying consensus, as represented in the abstract definitions, that equity is a key component for sustainability. Any singular disciplinary approach toward the achievement of sustainability is self-defeating. The tools for implementing sustainability represent attempts by separate disciplines at trying to slow the fall toward the bottom – there can only be a perpetuation of unsustainability when the voice of one discipline overpowers all others. The problem of unsustainability is an all-encompassing menace, with burdens to be carried by all professions, races, and nations; it isn't simply a problem for government officials, ecologists, economists, sociologists and architects to deal with within their separate disciplines. Collaboration is required – not just collaboration between a few similar professions, but instead, a dialogue between seemingly opposing professions and opposing stakeholder groups within a city is necessary to create a balance-seeking discussion. Neither one set of disciplinary tools, nor one profession can create such a balance-seeking process. The role of the professional and citizen in a sustainable city is to do more than just implement a few "green" architectural, economic, social, or ecological practices into policy or everyday life. There are many approaches that use the term "sustainable", when in fact the appropriate term should be "sustainability oriented" – that is to say, individual disciplinary concepts, like sustainability oriented architecture (often mistakenly called sustainable architecture), are not sustainable in and of themselves, but because of the positive sustainability quotient they would provide, could be appropriate tools or components of a sustainable city-region. These tools, if not applied in a holistic way, can inadvertently catapult a society even deeper into unsustainability. To create a net self-sufficiency at the scale of a city-system, various interdisciplinary groups and citizen stakeholders would use these "green" tools, and themselves become tools for the implementation of sustainability, in an engaged balance-seeking negotiation process

2.1 NATURAL RESOURCE AND LAND USE

Carrying Capacity – "[A] suitable total for the number of citizens cannot be fixed without considering the land and the neighboring states. The land must be extensive enough to support a given number of people in modest comfort, and not a foot more is needed."[31]
- Plato (360 B.C.)

Carrying Capacity – "Malthus argued…that if left unrestricted, human populations would continue to grow until they would become too large to be supported by the food grown on available agricultural land. He proposed that, while resources tend to grow arithmetically, population grows exponentially. At that point, the population would be restrained through mass famine and starvation. Malthus argued for population control, through "moral restraint", to avoid this happening. As the population exceeds the amount of resources the population decreases, since the lack of resources causes mortality to increase. This process keeps the population in check and ensures it doesn't exceed the amount of resources."[32]
- Thomas Malthus (1798)

Carrying Capacity –" Global warming, acid rain, depletion of the o-zone layer, vulnerability to epidemics, and exhaustion of soils and groundwater are all, as we shall see, related to population size. They are also clear and present dangers to the persistence of civilization. Crop failures due to global warming alone might result in the premature deaths of a billion or more people in the next few decades, and the AIDS epidemic could slaughter hundreds of millions. Together these would constitute a harsh 'population control' program provided by nature in the face of humanity's refusal to put into place a gentler program of its own. We shouldn't delude ourselves: the population explosion will come to an end before very long. The only remaining question is whether it will be halted through the humane method of birth control, or by nature wiping out the surplus."[33]
- Paul R. Ehrlich and Anne H. Ehrlich (1990)

Carrying Capacity – the number of people the earth can support. "[But the question is] "How many [people] is too many?" [It depends on how many people are] living at what level of material consumption and using what technologies to support their consumption habit." "How many people the Earth can support is in part a function of what humanity finds acceptable in terms of the average level of material well-being, distribution of material wealth, political and economic systems, technologies used, population stability, and risk of natural or human disaster." "Any effort to calculate carrying capacity for humans is

confounded by the fact that there are substantial individual and societal differences in the types and amounts of resources consumed, and the types and amounts of resources consumed change on an ongoing basis. The maximum population that might survive if only bare-minimum needs are met would be much higher than the optimal population. That high-maximum number should be distinguished from *cultural carrying capacity* or the number that could be supported with a certain cultural lifestyle or desired standard of living."[34]
- Herman E. Daly et al. (1992)

Ecocide – refers to humankind killing itself by destroying the environment.[35]
- Ophuls, William and A. Stephen Boyan, Jr. (1992)

Fair Earth Share – "The Earth has a limited area of ecoproductive land; or land generating resources that are useful to humans. If the Earth's ecoproductive land was equally divided among all humans, there would be 5 acres for each person. This is called a 'fair Earth share'".[36]
- Mathis Wackernagel and William Rees (1996)

Ecological Footprint – "Ecological footprint analysis is an accounting tool that enables us to estimate the resource consumption and waste assimilation requirements of a defined human population or economy in terms of a corresponding productive land area."[37]
- Mathis Wackernagel and William Rees (1996)

Environmental Space – "The basic concept was developed by Hans Opschoor from the Netherlands. Environmental space refers to the area that human beings can use in the natural environment without doing lasting harm to essential characteristics. This environmental space is a function of the carrying capacity of eco-systems, the recuperative efficiency of natural resources, and the availability of raw materials…Environmental space can, however, also be expanded when, say, polluted eco-systems are regenerated, biomass is increased through re-forestation, landscapes are re-cultivated, or desertification is reversed. The concept of environmental space acknowledges the diversity of possible human uses of the natural world. The functions served by nature include, supplying raw materials, dealing with waste, regulation of geo-chemical and biological cycles and not least, the integrity and beauty of a landscape or individual species. Forests can serve as an example. For centuries they were mainly seen as sources of wood. Forestry gradually established itself as a commercial venture. By now the ecological management of forests includes recognition of their importance for climate, regional water supplies, as environment for animals, and for hum recreation. The concept of environmental space essentially entails the ecological use of nature."[38]
- Sachs, Wolfgang et al. (1998)

Embodied Energy – "the energy that is used during the entire life cycle of the commodity for manufacturing, transporting and disposing of the commodity."[39]
- Mathis Wackernagel and William Rees (1996)

Sustainable Process Index (SPI) – "measures the potential impact (pressure) of processes (or more generally 'activities') on the ecosphere. The basic unit of the SPI is area. It is the total area that is required by any activity that exchanges material with the environment while maintaining the resource base (e.g. water, fertile land) as well as the natural assimilation capacity of the environment (e.g. for emissions, waste water, by-products). Integrated assessment of processes with the SPI aggregates resources as well as emissions to the three different ecological compartments air, water and soil. The lower the requirement of area for a given activity is, the lesser is the impact of this activity on the environment."[40]
- M. Narodoslawsky, and C. Krotscheck (2005)

Sustainable Area Budget (SAB) – "The SAB is an equitable land budget within which the citizens of a city can negotiate their way of life. This metric of sustainability means that in principle, each individual is entitled to one six billionth of the earth's regenerative capacity interpreted as land area. A city's working budget is thus the aggregated Sustainable Area Budget of its citizens. The SAB becomes a quantitative yardstick that provides the datum for the new scientific design process."[41]See the "Sustainability as an Essentially Contested Concept" section of this thesaurus.

Net Primary Productivity – "represents the total food resources of our planet and is determined by estimating the total amount of sunlight energy fixed through photosynthesis less the amount of energy used by plants for respiration. Along with all other consumers (and decomposers), humans completely depend on NPP for sustenance. The researchers' calculations included the amount of NPP used directly for food, fuel, fiber, or timber as well as other NPP consumed or lost indirectly through such activities as setting fires to clear land, replacing wild ecosystems with pastures or cropland, converting natural

areas to roads or cities, and so on. They concluded that *Homo sapiens* appropriates (consumes directly, co-opts, or eliminates) almost 40 percent of Earth's net primary productivity each year."[42]
- Vitousek et al. (1986)

Tragedy of the Commons – "The tragedy of the commons is a metaphor used to illustrate the conflict between individual interests and the common good. Hardin uses a hypothetical example of English Commons, shared plots of grassland used in the past by all livestock farmers in a village." "Each farmer keeps adding more livestock to graze on the Commons, because it costs him nothing to do so. In a few years, the soil is depleted by overgrazing, the Commons becomes unusable, and the village perishes." "The cause of any tragedy of the commons is that when individuals use a public good, they do not bear the entire cost of their actions. If each seeks to maximize individual utility, he ignores the costs borne by others. This is an example of an externality. The best (non-cooperative) short-term strategy for an individual is to try to exploit more than his share of public resources. Assuming a majority of individuals follow this strategy, the theory goes, the public resource gets overexploited."[43]
- Garrett Hardin (1968)

Lifeboat Ethics – A counter metaphor to "spaceship earth" That compares the earth to a lifeboat, or rather a series of lifeboats. Lifeboat ethics are conceived of as an operational guideline that seeks to avoid the "tragedy of the commons." "Metaphorically, each rich nation amounts to a lifeboat full of comparatively rich people. The poorer of the world are in other much more crowded lifeboats. Continuously, so to speak, the poor fall out of their lifeboats and swim for a while in the water outside, hoping to be admitted to a rich lifeboat, or in some other way to benefit from the "goodies" on board. What should the passengers on a rich lifeboat do?" 1. Take all the needy into the rich boat causing both the rich and the needy to drown; 2. Take in a few needy, doing away with any safety factor by reaching the carrying capacity of the boat (but discriminating which of the needy to allow to board becomes a problem); 3. Admit none of the needy to the rich boat and allow for the survival of those currently on board.[44]
- Garrett Hardin (1974)

Benign Demographic Transition – "1) If the per capita GNP rises the birth rate will fall; hence, the rate of population increases will fall, ultimately producing ZPG (Zero Population Growth), 2) The long-term trend all over the world (including the poor countries) is of a rising per capita GNP (for which no limit is seen.), 3) Therefore, all political interference in population matters is unnecessary; all we need to do is foster economic "development"…and population problems will solve themselves."[45]
- Garrett Hardin (1974)

Sustained Yield Forestry – trees must be given sufficient time to replace themselves before they are harvested. The area of forest land that can be harvested each year on a sustainable yield basis is equal to the area of forest land available divided by the number of years to maturity.[46]
- Cutter, Susan L. and William H. Renwick (1999)

Permaculture – (PERMAnent agriCULTURE or PERMAnent CULTURE) is a sustainable design system stressing the harmonious interrelationship of humans, plants, animals and the Earth.

- "To paraphrase the founder of permaculture, designer Bill Mollison: Permaculture principles focus on thoughtful designs for small-scale intensive systems which are labor efficient and which use biological resources instead of fossil fuels." "Designs stress ecological connections and closed energy and material loops. Each component in a system performs multiple functions, and each function is supported by many elements. Key to efficient design is observation and replication of natural ecosystems, where designers maximize diversity with polycultures, stress efficient energy planning for houses and settlement, using and accelerating natural plant succession, and increasing the highly productive 'edge-zones' within the system."
- "From Michael Pilarski, founder of Friends of the Trees, published in International Green Front Report (1988): Permaculture is: the design of land use systems that are sustainable and environmentally sound; the design of culturally appropriate systems which lead to social stability; a design system characterized by an integrated application of ecological principles in land use; an international movement for land use planning – [both urban and rural] – and design; an ethical system stressing positivism and cooperation. In the broadest sense, permaculture refers to land use systems which promote stability in society, utilize resources in a sustainable way and preserve wildlife habitat and the genetic diversity of wild and domestic plants and animals. It is a synthesis of ecology and geography, of observation and design. Permaculture involves ethics of earth care because the sustainable use of land cannot be separated from life-styles and philosophical issues.

- "Whereas permaculture ethics are more akin to broad moral values or codes of behavior, the principles of permaculture provide a set of universally applicable guidelines which can be used in designing sustainable habitats. Distilled from multiple disciplines—ecology, energy conservation, landscape design, and environmental science—these principles are inherent in any permaculture design, in any climate, and at any scale.[47]

Aquaculture – the production and husbandry of aquatic plants and animals in controlled environments

- *Husbandry* - the application of scientific principles to farming
- *Aquatic* - freshwater, brackishwater, or saltwater systems
- *Controlled* - directed or regulated; (a range of meaning) from production applying limited capital and management (low level of control, termed "extensive"), to production applying comprehensive capital and management (high level of control, termed "intensive")[48]

Organic agriculture – "Organic agriculture is a holistic production management system which promotes and enhances agro-ecosystem health, including biodiversity, biological cycles, and soil biological activity. It emphasizes the use of management practices in preference to the use of off-farm inputs, taking into account that regional conditions require locally adapted systems. This is accomplished by using, where possible, agronomic, biological, and mechanical methods, as opposed to using synthetic materials, to fulfill any specific function within the system."[49]
- FAO/WHO Codex Alimentarius Commission (1999)

2.2 ENERGY

Hard and Soft Energy Paths – "The hard path uses nonrenewables, nuclear power, and highly centralized energy production. The soft path shifts to the use of renewable forms of energy in decentralized ways."[50]
- Amory B. Lovins (1989)

Biofuel – any fuel that derives from biomass — recently living organisms or their metabolic byproducts, such as manure from cows. It is a renewable energy source that does not result in a net increase of carbon dioxide in the Earth's atmosphere since the carbon in biofuels was recently extracted from atmospheric carbon dioxide by growing plants. There are three forms of biomass that are combustible as biofuel: solids, such as wood, straw, human and animal waste, and agricultural waste; liquids, such as ethanol, methanol, vegetable oil, and biodiesel; and gases, such as methane and hydrogen. [51]

Methane digesters – a wastewater and solids treatment technology that processes human and/or animal waste under anaerobic conditions, yielding pure methane gas and reducing the volume of solids and treated liquids. The flammable methane can be used for cooking, heating, and generating electricity; "the solid matter left behind is a valuable soil amendment; and the liquids become an easily applied fertilizer with plant available nutrients and low pathogen levels."[52]
- Sustainable Conservation (2005)

Tidal Power – "is a means of electricity generation achieved by capturing the energy contained in moving water mass due to tides. Two types of tidal energy can be extracted: kinetic energy of currents due the tides and potential energy from the difference in height (or head) between high and low tides." [53]

Hydropower – is energy obtained from flowing water, by means of a dam, for electricity, or other mechanical devices, for non electric uses

Wind Power – is the extraction of the kinetic energy of wind by turbines.

Photovoltaic Cells – semi-conductor devices which generates electricity from sunlight

2.3 INDUSTRY

Product Life Extension – "Creating more durable, long-lived products [that] can contribute to sustainability by using natural resources efficiently and reducing waste and pollution."[54]

Dematerialization – "[It] literally means the loss of material; in IE it refers to a reduction in the amount of materials needed to produce or use a product. This can occur through changes in size, weight, product use, or even product life. Today it is easy to find examples of products made with less material than older products fulfilling the same functions. New desktop and palmtop computers are far more powerful than computers that occupied entire rooms or buildings a generation ago. Stereo systems, transistors, and other electronics have also undergone dramatic transitions in size. Several authors have suggested that reaching sustainability will require society, over the next few decades, to achieve dematerialization at much higher levels than to date, reducing materials intensity per unit of service by a factor of 10 or more."[55]
- Thomas E. Graedel and Braden R. Allenby (1995)

Dematerialization – "The main idea behind dematerialization is to reduce by a factor of 10, the material and energy flows humanity takes from nature over the next few decades. In other words, the material-and energy-intensities of all products and processes – from the cradle to the grave – must be massively reduced so as to keep 'natural capital' relatively intact and also to assure good prospects for future generations."[56]
- Wolfgang Sachs (1998)

Environmental Management System – "[EMS] refers to a management program extending beyond minimum compliance with environmental regulations." "A complete EMS would address organizational policies and procedures, personnel recruitment and training, facility design and operation, production processes, and more. Ideally, the EMS would not be limited to internal functions but would also address dealings with contractors, suppliers, dealers, customers, or representatives of other industries." "Typical components of an EMS would include an overarching statement of policy objectives, definition of environmental standards and practices, employee education programs, and prioritized environmental goals and target dates. Preferably, methods for projecting environmental costs are included so that these can be factored into financial decisions. Documentation is important, including an initial environmental assessment, ongoing regular evaluations, and an annual report for stakeholders, regulators, and others." "The most effective EMS will permeate every aspect of organizational function, for example, with employee performance evaluations reflecting progress toward environmental (as well as other) goals."[57]
- Ronald S. Smith Jr. (1998)

Industrial Metabolism – "The study of how energy and materials move through the economy [is] (IM). Developed initially by Robert Ayres, industrial metabolism involves tracing energy and materials from the initial extraction of natural resources through industrial processing and manufacturing, consumer use, and final disposal of all wastes. Energy and material flows can be traced at several scales: by site, firm, type of industry, regionally, nationally, or even globally."[58]
- Ernest A. Lowe et al. (1997)

Life Cycle Assessment – "[LCA] involves objective methods of holistically evaluating the environmental effects of a product through all stages of its life, including those stages beyond a manufacturer's direct control. For example, LCA for an auto would include the environmental effects of harvesting the minerals, energy, and so on used to manufacture each part; assembly of the vehicle; the process of getting it to a consumer; all of the fuel, oil, and so on used during operation by multiple owners; and the recycling, reuse, or landfilling of various parts when the car reaches the junkyard stage and beyond. Even the impacts of exploring, extracting, refining, and transporting the gas and oil should be included."[59]

Total Material Requirement – "[TMR], a sum of the physical material use of a national economy. TMR would include materials directly input to the economy for processing as well as "hidden" resource flows. In some countries, as much as 75 percent of the TMR involves hidden flows. These hidden flows involve materials that are not actually bought or sold but are moved during mineral extraction, harvesting of timber or crops, and infrastructure development."[60]
- Albert Adriaanse et al. (1997)

Recycling or Upcycling –"Recycling is more expensive for communities than it needs to be, partly because traditional recycling tries to force materials into more lifetimes than they were designed for – a complicated and messy conversion, and one that, itself, expends energy and resources. Very few objects of modern consumption were designed with recycling in mind. If the process is truly to save money and materials, products must be designed from the very beginning to be recycled

or even "upcycled" – a term we use to describe a return to industrial systems of materials with improved, rather that degraded, quality."[61]
- William McDonough and Michael Braungart (1998)

Waste Equals Food – "The principle 'waste equals food' means that all products and materials manufactured by industry as well as the *wastes* generated in the manufacturing process, must eventually provide nourishment for something new. A sustainable business organization would be embedded in an 'ecology of organizations,' in which the waste of any one organization would be a resource for another. In such a sustainable industrial system, the total outflow of each organization – its products and wastes – would be perceived and treated as resources cycling through the system."[62]
- The International Forum on Globalization (2002)

Industrial Ecology

The majority of discussions of industrial ecology tend to agree on the following elements.

- Industrial ecology is *a systems approach* drawing upon methods for analysis and synthesis from systems science.
- This systems approach focuses upon the *interaction of industrial systems and the ecological systems* (local to global) of which they are a part.
- IE seeks to redesign industrial activities to reduce the ecological impact of human activity to levels natural systems can sustain.
- IE is *interdisciplinary*, linking the research and planning of many fields, including ecology, engineering, economics, business management, and public administration and law, among others.
- IE studies the *flows of materials and energy* through the economy, ranging from those of an industrial or public facility to the planet. It seeks strategies to *increase the efficiency and reduce the impact* of these flows. (This study is often termed "industrial metabolism".)
- Industrial ecology seeks *transformation from a linear, wasteful economy to a closed-loop system* of production and consumption. In such a system industrial, governmental, and consumer discards would be reused, recycled, and remanufactured at the highest values possible.
- IE enables creation of *short-term* innovations with awareness of their *long-term* impacts. Similarly, it enables *local decision-making* with awareness of broader *regional and global impacts*.
- IE is a means of *balancing environmental protection with economic and business viability*. This balance must be dynamic, adapting to new knowledge about industry's impacts and nature's responses.
- IE is a major component in *"the science of sustainability",* with the role of designing the *transition path for industrial activities*, broadly defined. It offers an objective (though complex) foundation for *coordinating design of public policy* in environmental, technical, and environmental realms. [63]

- Indigo Development: RPP International's Industrial Ecology Research Center

Energy Cascading – "The term energy cascading is used in referring to the flow of energy utilization from high temperature to low temperature and a combination of effective energy utilization systems at different temperatures. In this process, heat transfer between large temperature differentials is avoided to the maximum extent, and instead, thermal recovery systems are installed at different temperature levels to effectively recover thermal energy as motive power. Such systems enable efficient utilization of thermal energy." "If, however, energy cascading is implemented at the demand site of heat and electricity, energy utilization can be complemented between thermal and electricity uses while maintaining availability of electricity, thus resulting in enhancing overall efficiency of the energy systems both at local and national levels."[64]

Eco-Efficiency – Doing more with less – is an outwardly admirable concept. But it works within the industrial system that originally caused the problem. It presents little more than an illusion of change.

- releases *fewer* pounds of toxic material into the air, water, and soil every year
- measures prosperity by *less* activity
- *meets or exceeds* the stipulations of thousands of complex regulations to keep people and natural systems from being poisoned too quickly
- produces *fewer* dangerous materials that will require constant vigilance from future generations
- results in *smaller* amounts of waste
- puts *fewer* valuable materials in holes all over the planet, where they can never be retrieved
- standardizes and homogenizes biological species and cultural practices

The Next Industrial Revolution can be framed as the following assignment: design an industrial system for the next century that:

- introduces no hazardous materials into the air, water, or soil
- measures prosperity by how much natural capital we can accrue in productive ways
- measures productivity by how many people are gainfully and meaningfully employed
- measures progress by how many buildings have no smoke- stacks or dangerous effluents
- does not require regulations whose purpose is to stop us from killing ourselves too quickly
- produces nothing that will require future generations to maintain vigilance
- celebrates the abundance of biological and cultural diversity and solar income[65]

– William McDonough and Michael Braungart (1998)

2.4 BUILT ENVIRONMENT

City-as-a-Hill Urban Model – a melding of the urban sensibilities of the medieval Italian hilltown built environment with the needs of modern industrial society into a new kind of urban model. The city fabric that would normally be placed on a hill now becomes a skin for the industrial and infrastructural needs located inside the hill. The "hill" is actually man-made, therefore the entire city essentially acts as one building. For more information, see the "Operational Definition (Prescriptive)" section. [66]

- Heidi Dumreicher Richard S. Levine, Ernest J. Yanarella, and Taghi Radmard (2000)

Passive solar design – "Passive solar systems use architectural elements in buildings to take advantage of natural cycles of sunlight and other elements in order to reduce the costs of building heating and cooling, without using mechanical elements. If mechanical elements are used, then the system is called active solar." [67]

Evaporative cooling – "Evaporative cooling is a system in which latent heat of evaporation is used to carry heat away from an object to cool it. The latent heat contains a considerable amount of energy, and carries away more heat than if the same temperature liquid was simply removed physically."[68]

Green roofs – placing a layer of soil and vegetation on top of the roofing membrane of a building allowing for increased insulation, slowed water run-off, and protection of the roofing membrane.

Artificial wetlands – a cascading, man-made water treatment "plant", that mimics the same water purification cycle that occurs in a natural wetland, while opening up the possibilities for agriculture and recreation

Sustainability-Oriented Architecture - works toward placing architecture in its correct role within the broader scope of sustainability. It attempts to address the four aspects of sustainable development: ecology, economy, equity (or social aspects), and place. In short it focuses on creating architecture that could support sustainability at the scale of the city-region.[69]

- Richard S. Levine, et al. (2005)

Sustainable Architecture – is a term currently in fashion, which is based on the fundamental misconception that sustainability can be achieved at the scale of the individual building. Because sustainable architecture has no generally agreed upon definition, the term is applied to any building that has included some combination of ecological features. Sustainability must be practiced at the scale of the city-region, orchestrating interwoven systems. Therefore, architecture, alone, cannot be sustainable.[70]

- Richard S. Levine, et al. (2005)

Green Architecture – is a vague term describing any architecture, which utilizes one or more ecologically friendly building methods and seeks to decrease the loads a building has on the environment.[71]

- Richard S. Levine, et al. (2005)

Ecological Architecture – is more specifically focused on the holistic measuring stick of ecology. However, there is no attempt to address the social or economic aspects of sustainability.

Sustainable Design – "[It] is the conception and realization of ecologically, economically and ethically sensitive and responsible expression as a part of the evolving matrix of nature."[72]
- William McDonough (1992)

Sustainable Design – "The term sustainable design is chosen over sustainable architecture because design can be both a verb (connoting a process) and a noun (connoting a result) and because design better conveys the interdisciplinary involvement needed to meet sustainable goals. As a process: Sustainable design is informed actions that aim at improving a project's contribution to natural, social, and economic prosperity throughout its lifecycle. As a result: The characteristics and ongoing operation of a sustainable design contribute to natural, social, and economic prosperity throughout its lifecycle."[73]
- NCARB Monograph: Sustainable Design (2000)

Arcology – "[Paolo Soleri] envisions an architectural ecology...that would build a town or a city as a single unit. It would attain greater compactness than existing towns and cities by abolishing all motor transportation. There would then be no need for the freeways, streets, parking lots, and filling stations that occupy so much of the land in modern towns and cities. This would, at the same time, bring everything much closer together, so that the abolition of motor transportation also does away with much of the need for it!"[74]
- Herman E. Daly and John B. Cobb Jr. (1989)

Community Gardens and Urban Agriculture – "[They] can help alleviate poverty and hunger, absorb pollution, green cityscapes, bolster the local economic base, reduce the resources flowing into cities, and reduce the waste flowing out. In the U.S., foods on a supermarket shelf have been shipped an estimated average of 2000 kilometers; storage and transportation impacts almost disappear with use of community-grown foods."[75]
- H. Patricia Hynes (1996)
- Jac Smit and Joe Nasr (1999)

Buy-local Campaigns – These campaigns help local food businesses thrive and prevent money from "leaking" from the local economy. This protection of the local is also expressed by hundreds of regional campaigns against the entry of global franchises like McDonald's and Wal-Mart.
Farmers' Markets – Thriving in many parts of the world, farmers' markets are now also being rediscovered and supported throughout industrial countries. These markets are ways of directly connecting consumers with local producers, often organic farmers, who can keep prices down by avoiding distribution costs.
Local Food Co-ops. – These are small retail outlets, similar to farmers' markets but where financial benefits are shared by producers and consumers.
Urban Gardens – Urban gardens are one of the most original and revitalizing movements among urban dwellers, especially in Northern countries where access to natural sites may be difficult. Making use of empty lots, small patches of private property, public parks, urban gardens enable city-dwellers to grow their own organic foods.[76]
- The International Forum on Globalization (2002)

2.5 SOCIOLOGY

Local Identity – "In the context of sustainability, the local identity is the starting point for future scenarios: the local potential in its singularity will be the glue that holds together the integrity of [a place]."[77]
- Heidi Dumreicher and Bettina Kolb (2005)

Emotional Co-ownership – a strong attachment to a place that results in an interest from local citizens in the perpetuation of the valued qualities of the place. Most often this attribute is found in an empowered citizen who is involved in the decision making process of her locality.[78]
- Heidi Dumreicher and Bettina Kolb (2003)

Social capital--"The central premise of social capital is that social networks have value. Social capital refers to the collective value of all 'social networks' [who people know] and the inclinations that arise from these networks to do things for each other ["norms of reciprocity"]."

a. "information flows (e.g. learning about jobs, learning about candidates running for office, exchanging ideas at college, etc.) depend on social capital
b. norms of reciprocity (mutual aid) are dependent on social networks.
    --Bonding networks that connect folks who are similar sustain particularized (in-group) reciprocity.
    --Bridging networks that connect individuals who are diverse sustain generalized reciprocity.
c. Collective action depends upon social networks (e.g., the role that the black church played in the civic rights movement) although collective action also can foster new networks.
d. Broader identities and solidarity are encouraged by social networks that help translate an 'I' mentality into a 'we' mentality."

"When a group of neighbors informally keep an eye on one another's homes, that's social capital in action. When a tightly knit community of Hassidic Jews trade diamonds without having to test each gem for purity, that's social capital in action. Barn-raising on the frontier was social capital in action, and so too are e-mail exchanges among members of a cancer support group. Social capital can be found in friendship networks, neighborhoods, churches, schools, bridge clubs, civic associations, and even bars. The motto in Cheers 'where everybody knows your name' captures one important aspect of social capital."[79]
- Robert Putnam (2000)

Local Social Infrastructure – "This infrastructure influences the chances, possibilities and life quality in [a place]: if there exists a good local infrastructure for the social and cultural life, the chances for a future development are much higher than in a place with deteriorated local [infrastructure]. [For example,] the availability of a school, a kindergarten or [an assisted living facility] gives the dwellers different possibilities of life styles and chances to participate in the social life [of their place]".[80]
- Heidi Dumreicher and Bettina Kolb (2005)

Local Cultural Infrastructure – "creates the chances for the cultural identity of a local place and its inhabitants. If many dwellers participate in a local dancing group, this activity will make the community actions…more lively and contribute to the sense of place, even for the people who are not actively involved in this endeavor." "The cultural possibilities will also give the community [a] specific local identity, which is a necessary condition for a good relationship with the region."[81]
- Heidi Dumreicher and Bettina Kolb (2005)

Transregional Information – "the life quality in a town depends on a good balance between the near and the far away, between the well known and the unknown."[82]
- Heidi Dumreicher and Bettina Kolb (2003)

Civil Society – "Civil society refers to the arena of uncoerced collective action around shared interests, purposes and values. In theory, its institutional forms are distinct from those of the state, family and market, though in practice, the boundaries between state, civil society, family and market are often complex, blurred and negotiated. Civil society commonly embraces a diversity of spaces, actors and institutional forms, varying in their degree of formality, autonomy and power. Civil societies are often populated by organisations such as registered charities, development non-governmental organisations, community groups, women's organisations, faith-based organisations, professional associations, trades unions, self-help groups, social movements, business associations, coalitions and advocacy groups."[83]
- London School of Economics, Centre for Civil Society

2.6 ECONOMY

Steady-State Economy--an economy with constant stocks of people and artifacts, maintained at some desired, sufficient levels by low rates of maintenance 'throughput', that is, by the lowest feasible flows of matter and energy from the first stage of production ... to the last stage of consumption"[84]
- Herman E Daly (1977)

Sustainable Global Economy
Hazel Henderson offers a critique of globalization which is creating a bubble economy at the cost of real, more local enterprises and livelihoods. She argues for the use of systems thinking and a more holistic approach as a way of breaking out of the narrow prism of GDP and market pricing that dominates conventional economic thinking. She sets out a vision of the changes required to reshape the global economy toward social justice and ecological sustainability at every level, from the global to the local and personal. However, her theory is aimed only at the economic aspect of unsustainability and lacks an operational process for achieving sustainability.[85]
-- Hazel Henderson (1999)

Four types of capitals:
"1. Ecological capital is defined as stocks and flows of energy and matter, and the physical states, such as climatic conditions or ecosystem characteristics, to which they give rise. The stocks include the gases of the atmosphere, including the ozone layer, renewable and non-renewable resources, the absorptive, centralizing and degrading capacities of the environmental media air, water and land, and countryside and wilderness; the flows include the biospheric cycles of carbon, nitrogen and water, and the nutrient flows of ecosystems. From these stocks and flows derive the environmental functions which are the subject of the sustainability standards above, i.e. an atmosphere that yields climate stability, an ozone layer that filters out ultraviolet light, biodiversity that yields ecosystem stability and resilience, the provision of resources, the degradation of wastes, environmental amenity and inspiration and environmental security.
2. Human capital comprises the abilities of individual people to do productive work and therefore includes physical and mental health, strength, stamina, knowledge, skills, motivation and a constructive and cooperative attitude.
3. Social/organizational capital comprises the social structures and institutions which enable individuals to maintain and develop their human capital and be productive and include firms, trade unions, families, communities, voluntary organizations, legal/political systems, educational institutions, the health service, other social institutions (e.g. the welfare state), systems of property rights, financial institutions, etc.
4. Manufactured capital comprises material goods — tools, machines, buildings, infrastructure — which contribute to the production process but do not become embodied in the output and, usually, are 'consumed' in a period of time longer than a year. Intermediate goods, in contrast, either are embodied in produced goods (e.g. metals, plastics, components) or are immediately consumed in the production process (e.g. fuels)."[86]
- Paul Ekins (2000)

Natural Capital – "Let us take a close look at this 'natural capital.' First of all, and most obviously, there are the fossil fuels. No one, I am sure, will deny that we are treating them as income items, although they are undeniably capital items. If we treated them as capital items, we should be concerned with conservation; we should do everything in our power to try and minimize their current rate of use; we might be saying, for instance, that the money obtained from the realization from these assets – these irreplaceable assets – must be placed into a special fund to be devoted exclusively to the evolution of production methods and patterns of living which do *not* depend on fossil fuels at all or depend on them only to a very slight extent. These and many other things we should be doing if we treated fossil fuels as capital and not as income…Fossil fuels are merely a part of the 'natural capital' which we steadfastly insist on treating as expendable, as if it were income, and by no means the most important part. If we squander our fossil fuels, we threaten civilization; but if we squander the capital represented by living nature around us, we threaten life itself."[87]
- E.F. Schumacher (1973)

Ecological Economics—"studies the relationships between economic systems and ecological systems. This trans-disciplinary field emphasizes both the economic opportunities offered by the environment and the limits that the environment places on economic growth. Its goal is sustainability, and its adherents study how economic policy mechanisms can contribute to sustainability and benefit humanity"[88]
- Paul Ekins and Manfred Max-Neef, eds. (1992)

Externalities—"are negative side-effects suffered by someone other than those immediately involved in a financial transaction. When measuring the value of what has been produced, it might seem obvious that both positive and negative effects should be included in the sum value. But declaring a negative effect as external is taken as justification to ignore it. Often, anything difficult to quantify is considered external and given no consideration."[89]

Discount Rates--"One assumption of conventional economics is that all resources belong to the present generation and are worth more today than they will be in the future. The idea is that, because of inflation, the same amount of money, natural resources, or equipment will bring less returns next year than it can bring this year. So standard accounting systems use discount rates to calculate or *discount* the value of future returns against the present. This practice implicitly suggests that if calculations were extended far enough into the future, the resources would be worth nothing. Because it encourages using resources in the present rather than conserving them for the future, discounting is at odds with sustainable resource use."[90]

Conventional Neoclassical Economics—"through discounting, substitutability, externalities, and in other ways, creates bias in our accounting systems and skews decision-making processes at many levels. As individuals, organizations, communities, and nations, we make purchases, choose practices, develop technologies, or establish policies that do not reflect their true costs in the present or future. This hinders progress toward becoming a sustainable society."[91]

Service Economy--"In a service economy, the buyer pays for the use or performance of a product system rather than just the product itself. Value is tied less to production and more to the costs of providing results during product use. A service economy is thus based not on the exchange of goods but on their utilization. The economy is fed by new service loops and skilled labor for reusing, reconditioning, and upgrading goods. A special application of the principles of industrial ecology, this concept bridges corporate profit motives and missions, customer needs, the functioning of the economy, and the goal of sustainability." [92]
- Walter R. Stahel (1994)

Community Banks and Loan Funds – Run by community boards, these increase capital available for local residents and businesses and allow people to invest in their neighborhoods rather than in distant corporations. Such banks favor small-scale local activity over global corporate activity.
Local Currencies – Growing in popularity, these alternative scrips used only in communities enable people to avoid the dominant currencies and keep money within the local community. Local currency schemes are similar in intent to Local Exchange Trading Systems (LETS), which are large-scale barter systems for local communities, often facilitated by a central credit and debit accounts system. Among the leading examples of a successful LETS program is the Berkeley Regional Exchange and Development (BREAD).[93]
- The International Forum on Globalization (2002)

2.7 DECISION MAKING PROCESS

Subsidiarity- "favoring the local whenever a choice exists. In practice Subsidiarity means that all decisions should be made at the lowest level of governing authority competent to deal with them." [94]
- The International Forum on Globalization (2002)

The Precautionary Principle – "When a practice or product raises potentially significant threats of harm to human health or the environment, precautionary action should be taken to restrict or ban it, even if there is scientific uncertainty about whether or how it is actually causing that harm. Because it can take years for scientific proof to of harm to be established – during which time undesirable or irreversible effects may continue to be inflicted – the proponents of a practice or product should bear the burden of proving it is safe."[95]
- The International Forum on Globalization (2002)

Fully Conscious Revolution – "Can we move nations and people in the direction of sustainability? Such a move would be a modification of society comparable in scale to only two other changes: the Agricultural Revolution of the late Neolithic and the Industrial Revolution of the past two centuries. Those revolutions were gradual, spontaneous, and largely unconscious. This one will have to be a fully conscious operation, guided by the best foresight that science can provide… If we actually do it, the undertaking will be absolutely unique in humanity's stay on Earth."[96]
- William D. Ruckelshaus (1989)

"Think globally, act locally" – "Acceptance of the reality that humans do not "manage" the planet calls for new models of organization, governance, and decentralization and wherever possible the localizing of production, consumption and participation, together with the democratic formulation of planetary agreements, declarations of principles, and the rights and responsibilities of all people. This "thinking globally, acting locally" formula can inform local action with the understanding of the requirements of planetary interdependence and limits. It can also fuse thought and action, a prerequisite for integrated personalities (i.e. whole people) functioning in integrated whole systems, recognized by psychologists, anthropologists, revolutionaries, and theologians." "Increasingly we see the denouement of the nation-state as a viable unit of governance; becoming too big for the small problems of its own local populations and at the same time too small for the big problems of global relations and ecosystems. Nation-states are rendered operational by the now failing macro-economic management in centralized political decisions based on the large statistical aggregates of the formal, monetized GNP economy. At the other end of the scale are the undervalued manual tasks, rural and agricultural life, and the unpaid work of the nonmonetized, "informal" economy of household production, gardening, canning, home repairs, nurturing and parenting, volunteer community service, and all the cooperative activities that permit the over-rewarded competitive activities to appear "successful." Hierarchies become bottlenecks; excessively conceptual governance becomes divorced from reality whether in Washington, Brussels, or Moscow, where bureaucrats try to govern by manipulating statistical illusions, using highly aggregated, averaged data that do not fit one single real-world case or situation." [97]
- Hazel Henderson (1981)

Global Thinking – "Properly speaking, it is not possible to <u>think</u> globally. Those who have "thought globally" (and among these the most successful have been imperial governments and multi-national corporations) have done so by means of simplification too extreme and oppressive to merit the name of thought. Global thinkers have been, and will be, dangerous people. So do national thinkers tend to be; we now have national thinkers in the northeastern United States who look upon Kentucky as a garbage dump."
– Wendell Berry

Systems Thinking – "involves the use of various techniques to study systems of many kinds. It includes studying things in a holistic way, rather than purely reductionist techniques. It aims to gain insights into the whole by understanding the linkages, interactions and processes between the elements that comprise the whole "system". Systems thinking can help avoid the silo effect, where a lack of organizational communication can cause a change in one area of a system to adversely affect another area of the system.
Systems thinkers consider that:
· a "system" is a dynamic and complex whole, interacting as a structured functional unit in equilibrium
· information flows between the different elements that compose the system
· a system is a community situated within an environment
· information flows from and to the surrounding environment via semi-permeable membranes or boundaries"
"Systems thinkers are particularly interested in studying systems because changing a system frequently leads to counterintuitive system responses. For example feedback loops may operate to either keep the organization in check or unbalance it." "Traditional decision making tends to involve linear cause and effect relationships. By taking a systems approach, we can see the whole complex of bidirectional interrelationships. Instead of analysing a problem in terms of an input and an output, for example, we look at the whole system of inputs, processes, outputs, feedback, and controls. This larger picture will typically provide more useful results than traditional methods. System thinking also helps us integrate the temporal dimension of any decision. Instead of looking at discrete "snapshots" at points in time, a systems methodology will allow us to see change as a continuous process. Systems Thinking is a worldview based on the perspective of the systems sciences, which seeks to understand interconnectedness, complexity and wholeness of components of systems in specific relationship to each other." [98]

STELLA – a systems dynamics modeling used to facilitate systems thinking.

Sustainability Engine™- "Still under development, the Sustainability Engine™ is a powerful software tool that integrates the capabilities of intelligent CAD, facilities management, and GIS software with the systems dynamics modeling software utilized in the SUCCESS project. The Engine will serve as the principal design, feedback, and management tool in the negotiation of sustainable cities. It will be able to reproduce stakeholder proposed scenarios as both physical designs and energy and material flow models. Within the Engine will be compiling module libraries of building blocks that contain universally applicable scientific data as well as data obtained from local conditions. These attributes may include embodied energy, distance from source, cost, availability within the region, labor requirements, recyclability, insulation value, land use implications, energy and material flow connections to other regenerative systems, and the various inputs and outputs involved in the functioning of the module within the city-system. These modules will function as plug-in, "free body" objects that provide inputs and outputs when attached to a larger sustainable city scenario model. When it is fully developed the Engine will be an essential technical means and public policy tool for facilitating a democratic participatory stakeholder process."[99]
- Richard S. Levine, Michael Hughes, and Casey Ryan Mather (2005)

2.8 BUREAUCRATIC STRUCTURES

Environmental Certification – "Government agencies and independent groups can use eco-labeling or green certification processes to indicate the environmental merit of products or services. Elements of concern might include recycled content, recyclability, extended product life, durability and reparability, content or use of toxics, total mass, embedded energy, and the efficiency of manufacturing processes. Some potential for misuse exists, such as when a company tries to gain a market advantage by 'greenwashing' a product, perhaps claiming it meets new environmental management goals when the goals are very relaxed and/or progress has been minimal. However, environmental labeling has already contributed to real progress for some types of products, such as the influence of the U.S. Environmental Protection Agency's 'Energy Star' program on energy use by computers and office equipment."[100]

LEED – "The LEED (Leadership in Energy and Environmental Design) Green Building Rating System® is a voluntary, consensus-based national standard for developing high-performance, sustainable buildings.
LEED was created to:

- define "green building" by establishing a common standard of measurement
- promote integrated, whole-building design practices
- recognize environmental leadership in the building industry
- stimulate green competition
- raise consumer awareness of green building benefits
- transform the building market

LEED provides a complete framework for assessing building performance and meeting sustainability goals. Based on well-founded scientific standards, LEED emphasizes state of the art strategies for sustainable site development, water savings, energy efficiency, materials selection and indoor environmental quality. LEED recognizes achievements and promotes expertise in green building through a comprehensive system offering project certification, professional accreditation, training and practical resources."[101]
- United States Green Building Council (2005)

Green Taxes –"The idea of taxing pollution and waste has a solid foundation in mainstream fiscal and economic thinking. The idea is favorable to some economists and business leaders, who think that existing tax schemes impose efficiency costs and slow economic growth. The effects would be similar whether the fees were collected by new taxes per se or by auctioning emissions permits. Green taxes could be applied in such areas as climate change/energy use, congestion, pollution, and solid waste. Despite concerns that such a tax might be regressive, analysis has shown that this type of tax policy shift could occur without altering the distribution of personal taxes in relation to household income. France was the first country to impose a direct tax on units of pollution."[102]
- Gilbert Metcalf (1998)

3. SUSTAINABILITY AS AN ESSENTIALLY CONTESTED CONCEPT

For John Locke and Adam Smith, the goods that men desire from the earth were not so scarce that they must inevitably be fought over.[103] Their attitudes were shaped in large part by the discovery of the New World, and it seemed rather foolish to them to fight over scarce goods when one can simply apply his intelligence and labor to an unexploited part of the global commons where the carrying capacity has not yet been reached. Locke and Smith's conception of an endless ecological frontier shaped the modern political worldview and has led to today's imperialistic globalized economy that offers up economic growth as the cure for any number of societal problems (something Herman Daly has called "growthmania").

However, the Lockean era of economics, politics, and place-making which has been formulated around the assumption of infinite territory and resources is necessarily coming to a close. William Ophuls has written, "the Great Frontier is no more: the New World has been filled up, the wealth has been appropriated, and our basic institutions need reexamination."[104] The realization of ecological scarcity led the economist Kenneth Boulding to reject what he called the "cowboy economy" of the past and instead offered the image of "spaceship earth," a vessel with limited resources and one in which the passengers feel the effects of their pollution and overuse of these resources. Donella and Dennis Meadows' 1972 Report to the Club of Rome, *The Limits to Growth*, used systems dynamics modeling software to determine a host of ecological limits that are on a course of "overshoot and collapse" because of exponential growth in resource consumption and population among other factors.

The growing recognition in the 1970's of the unsustainability of modern man's relationship to the earth soon became manifest in a wide array of political ideologies from Marxists, anarchists, and feminists on the far left to libertarians and primitivists on the far right. These early movements have been summarized under the term "arcadian environmentalism" because the majority of the thought on how to counteract unsustainability was focused on integrating man back into nature and was generally accompanied by a kind of social edenism and anti-urban development.

The dire warnings that characterized the 1972 report to the Club of Rome and were reflected in arcadian environmentalism have shifted through the 1980's and 1990's increasingly toward a new era of environmental optimism. The Club of Rome's 1995 report summarizes this shift by saying, "The early phase—when key actors in this process felt they faced 'no win'…or 'zero-sum'…outcomes—has been replaced by a phase in which key actors…have been looking for 'win-win' outcomes."[105] Through embracing the Brundtland Commission's conception of sustainable development, which called for "a new era of economic growth—growth that is forceful and at the same time socially and environmentally sustainable,"[106] business leaders began to recognize an opportunity not to fight the environmental movement as it had in the past but rather, as one businessman said, to "make the environmental issue *our* issue."[107] This more recent environmental movement, based on continued growth achieved through more efficient and more responsible technology has been labeled "promethean environmentalism."

While sustainability and sustainable development have been rallying cries for social movements and NGO's and buzzwords of global conferences, their true meanings have remained highly contested. The Brundtland Commission definition of sustainable development has been the most popular and has served as a minimalist definition around which most of the current discussion of sustainability has been framed. Its abstract nature, however, has served to conceal as much as it reveals, and thus it has only been helpful in forming a broadly based social consensus. Recently, Simon Guy and his associates, Simon Marvin and Graham Farmer, in light of the myriad interpretations and competing logics of sustainability, have deemed sustainable architecture, sustainable cities, and sustainable development "essentially contested concepts." Applying a social constructivist analysis to sustainability, Guy and his colleagues argue that the "separate but not autonomous" logical frameworks that create the discourse on sustainability effectively prohibit the search for a more encompassing framework of which these individual logics are a part. Lacking an objective datum to anchor the substance of sustainability, for Guy and his associates the sustainable city becomes merely "an open or empty concept which is filled by sets of competing claims about what the sustainable city might become."[108]

Without denying the essential contested character of sustainability, the work of the Center for Sustainable Cities at the University of Kentucky and Oikodrom, the Vienna Institute for Urban Sustainability suggests a way out of the conundrum in which social constructivism places sustainability.[109] This avenue lies in working back into the linguistic thicket and eco-scientific renderings of sustainability in order to build the theoretical base of an operational process for actually achieving sustainability—a process that seeks to synthesize and transcend the various competing logics of sustainability expressed in the work of Guy, Marvin and Farmer through the establishment of a process with an objective metric, working within a clear operational definition of sustainability.

First, it is necessary to examine a common misunderstanding within the sustainability movement: the difference between growth and development. While many, including the famous Brundtland Commission, use the terms "sustainable growth" and "sustainable development" interchangeably; Herman Daly and John Cobb have lucidly presented a sharp distinction between the two. Daly and Cobb define 'growth' as "quantitative expansion in the scale of the physical dimensions of [a] system," while defining 'development' as "qualitative change of a physically non-growing…system in

dynamic equilibrium with the environment."[110] They establish the nature of the earth as non-growing and argue that "any system of a finite and non-growing earth must itself also eventually become non-growing."[111] The term "sustainable growth" then becomes self-contradictory. Similarly, Michael Redclift has shown that complex natural ecosystems initially pass through a phase where growth and production is favored, to a mature and sustainable developmental phase where diversity, regeneration and stability are fostered.[112] Therefore, as Daly and Cobb write, "growth will become unsustainable eventually…but sustainable development does not become self-contradictory."

Daly and Cobb's rejection of the concept of sustainable growth runs parallel to their rejection of the promethean environmentalist's or "human exceptionalist" school's theoretical means of facilitating this growth: the idea that all natural resources can infinitely be replaced by humanly created substitutes. This theoretical economic tool of substitutability embedded in what has come to be called "weak sustainability," is dismissed by Daly and Cobb in favor of "strong sustainability" that requires "maintaining both humanly created and natural capital intact separately, on the assumption that they are complements rather than substitutes in most production functions."[113] In 1999, Eric Neumayer wrote in favor of the concept of strong sustainability but lamented that "so far there does not exist a comprehensive study measuring SS [Strong Sustainability]."[114] After exploring and rejecting various measures including sustainability indicators and the ecological footprint analysis, in 2000 the Center for Sustainable Cities with Oikodrom formulated the Sustainable Area Budget (SAB)[115] to serve as a yardstick to measure and operationalize strong sustainability.

The Sustainable Area Budget is an equitable land budget from which a city-region must satisfy its needs now and into the future. This metric of sustainability means that in principle, each individual is entitled to one six billionth of the earth's regenerative capacity interpreted as land area. A city's working budget is the aggregated Sustainable Area Budget of its citizens. Within this fixed land budget, the citizen-stakeholders of a city-region are free to negotiate a way of life according to their own locale, culture and creativity, as long as no harmful imbalances are exported beyond their SAB.

The Sustainability Indicator method, currently the most popular approach among policy-makers, creates checklists of indicators, intended to measure and incrementally reduce the levels of unsustainability. By disaggregating the problem of unsustainability into many sub-problems, it makes it easier to deal with them in isolation. However, at no point on any of the separate indicator scales or on the aggregated scale is there a place where sustainability can actually be said to exist.

The Ecological Footprint method is a highly quantitative approach that is effective as an analytical tool for assessing the environmental load of a city by calculating the territory appropriated by current human activities. While metaphorically and visually, the approach is a powerful and compelling educational tool, it is not useful in shaping a solution once the magnitude of the problem is recognized because it urges stakeholders to embark upon a succession of separate, incremental movements to reduce their town's Ecological Footprint, rather than dealing with the town as a whole system. Thus, it fails to understand and grapple with the synergistic consequences of the many causes of unsustainability.

By contrast, the Sustainable Area Budget, begins from the premise that sustainability is an ongoing, balance-seeking process, not a collection of incremental steps. Through seeking a quantitative yardstick from which to launch a policymaking process of democratic deliberations, it produces a paradigm shift from trying to reduce environmental loads, to collectively restructuring a place's processes and lifestyle within an equitable budget of the earth's ecological resources. In doing so, the SAB allows the sustainability agenda to advance beyond the boundaries of weak sustainability into a warranted state of strong sustainability.

While the Sustainable Area Budget does not completely overcome the essentially contested character of sustainability when it is represented at the building scale (Sustainability Oriented Architecture Scale), when the scale of discourse is raised to the scale of the city-region – to the scale at which a whole system may be studies – adequate room becomes available for each of the "competing logics of sustainable architecture" (see below). Working with the Sustainable Area Budget at the scale of the city-region rehabilitates sustainability as a substantive, synergistic, and synoptic concept that directs us to working models in nature and unfolding possibilities in the nature-societal nexus as inspirations for such strong and robust strategy for affecting change.

Homo Economicus – "the self-enclosed individual whose relations to others are external;" a conception of man that stems from possessive individualism, specifically Lockean Liberalism, and has created the foundation for the modern capitalist economy.[116]
- Herman E Daly and John B. Cobb Jr. (1989)

Globalization – describes the changes in societies and the world economy that are the result of dramatically increased international "free trade" and cultural exchange.

Globalization (Economic Globalization, or Corporate Globalization or Neo-liberalism)

- "Promotions of hyper-growth and unrestricted exploitation of environmental resources to fuel that growth
- Privatization and commodification of public services and of remaining aspects of global and community commons
- Global cultural and economic homogenization and the intense promotion of consumerism
- Integration and conversation of national economics, including some that were largely self-reliant, to environmentally and socially harmful export-oriented production
- Corporate deregulation and unrestricted movement of capital across borders
- Dramatically increased corporate concentration
- Dismantling of public health, social, and environmental programs already in place
- Replacement of traditional powers of democratic nation-states and local communities by global corporate bureaucracies"[117]

-The International Forum on Globalization (2002)

Growthmania--" Growth is the most universally accepted goal in the world ... Economic growth is held to be the cure for poverty, unemployment, dept repayment, inflation, balance of payment deficit, pollution, depletion, the population explosion, crime, divorce, and drug addiction ... This is growthmania."[118]
- Herman Daly (1991)

Comparative Advantage – according to this economic theory "every country should produce products over which it has a relative advantage; thus, some countries now specialize in single crops like, coffee, sugar cane forest products or high-tech assembly. Theoretically, they can meet their other needs by using the earnings from these specialized exports to buy goods and services over which others have an advantage."[119]
-The International Forum on Globalization (2002)

Comparative Advantage – This theory was established by David Ricardo in 1817. "He also assumed, however, that investment capital is immobile and confined within national boundaries. If this were not the case, then investment capital would flow to the country with the absolute advantage in production and other nations would suffer. The irony here is that proponents of globalization endorse a policy of capital mobility between nations as a development strategy in spite of the fact that their understanding of the advantages of globalizations is premised on a theory developed by Ricardo that assumes that this mobility does not exist."[120]
- Robert L. Nadeau (2003)

The Economics of Spaceship Earth – The view that the "cowboy economy" of the past was no longer viable and that economists need to drop their "frontier" mentality by recognizing that no true frontiers remain on Earth and that planetary limits should lead us to think in terms of "the 'spaceman' economy, in which the earth has become a single spaceship, without unlimited reservoirs of anything, either for extraction or for pollution"[121]
- Kenneth E. Boulding (1966)

Gaia – "The model, in which the earth's living matter, air, oceans, and land surface form a complex system that can be seen as a single organism," of which humans and all other living things are a part, "[that] has the capacity to keep our planet a fit place for life."[122]
- J. E. Lovelock (1979)

Overshoot and Collapse – "If the signal or response from the limit is delayed, and if the environment is irreversibly eroded when overstressed, then the growing economy will overshoot its carrying capacity, degrade its resource base, and collapse. The result of this overshoot and collapse is a permanently impoverished environment and a material standard of living much lower than what could have been possible if the environment had never been overstressed."[123]
- Donella H. Meadows, Dennis L. and Jørgen Randers (1992)

Ecologism – "has long been a 'convincing box in which all kinds of alternative ideas and people fit,' despite its many apparent paradoxes."[124]
- Martin W. Louis (1992)

Varieties of Eco-radicalism

- Anti-humanist anarchism – "all forms of life (in some cases, nonliving natural entities as well) have intrinsic worth and therefore an inherent right to exist, regardless of their potential utility to humanity" The whole of nature is much greater than the sum of its parts. People must re-integrate with nature through decentralized, small scale communities and self participatory democracy and reduce consumption. Western thought is morally bankrupt and is leading us to destruction. Deep Ecology
- Primitivism – "The only way to exorcise this malignancy [man] is for the vast bulk of humanity to disappear, with the few survivors renouncing all technological innovations made over the past 10,000 years."
- Humanist eco-anarchism – anthropocentric, but otherwise, the same as other deep ecological sects. "Ecological health is absolutely inseparable from social equality." Bookchin and his school of "social ecology" dominates this sect. More popular in Europe, because "the explicit *humanism* as social ecology is repulsive to most American eco-radicals"
- Green Marxism – "The root of the problem [is] in sociopolitical structures of rather than in the mental universes of individuals" Some Marxists go so far as to deny all individuality. The usual guilt felt by the "greens" that live inconsistent lives with their beliefs is brushed aside and deemed "a figment of bourgeois individualism." Autarkic decentralization that is promoted by most deep ecologists is not endorsed by the Green Marxists, in fact their goal is to "redden the mainstream Greens." The most influential Marxist edict amongst the radical environmental movement is that which touts the evils of capitalism. "Marx himself, in addition to being anthropocentric, supported political centralization and Western imperialism, while applauding virtually all forms of technological advance. Moreover, few eco-Marxists express concern for the loss of biological diversity, a stance not likely to gain much favor in a movement founded in large part on the principle of biospheric egalitarianism."
- Radical eco-feminism – "men and women are different in their essences [and] they intrinsically think and feel differently," and are "considered by nature close to the natural world than are men." "To avert crisis and restore both the earth and humanity we must embrace a female, compassionate, nonhierarchical, nondualistic, ecological mode of thought structured around relationships rather than individual entities."[125]
  - Martin W. Louis (1992)

Arcadian environmentalism (exemplified by the deep ecology of anti-humanist anarchism) seeks to integrate man back into nature, by establishing bio-centric egalitarianism within a utopian vision of small scale, anti-urban Social Edenism, operating in a steady-state economic equilibrium. "Think globally: act locally"[126]
- Martin W Louis (1992)

Promethean environmentalism (Sustainable Development paradigm *per* Brundtland) accepts the reality of current political, economic, ecological, and social paradigms but seeks to reconcile the negative ecological impacts and social inequality built into these systems through continual reform and economic growth based on increasing technological efficiency. "Think and act at multiple scales."[127]
- Martin W. Louis (1992)

Deep ecologists are the most extreme group holding the perspective that further development is not sustainable. Adherents of *deep ecology* question the fundamental attitudes of Western society and consider the concept of sustainable development unacceptably anthropocentric. Deep ecologists believe that all natural things have an inherent right to exist. They believe that humans should not be the central focus and that humans have no right to impact the natural world except to meet vital needs. They support the idea of *appropriate technology* but tend to view modern technology as part of the problem rather than part of the solution. They give little value to technological progress or material consumption, believing that a huge decrease in world population and largely pre-industrial lifestyles are the most ethical and truly sustainable choices.[128]
- Bill Devall and George Sessions (1985)

Appropriate technology – advances in science that are scrutinized and are deemed usable within place-specific social and ecological systems. Typically, this means the technology is small scale, emits little or no pollution, and does not require extensive consumption of natural resources; however, some argue that forms of high technology are also appropriate.[129]
- Martin W. Louis (1992)

Technophobia – "The belief that technological advance bears much, if not most, of the responsibility for the ecological crisis," and thus many or all forms of modern technology should be abandoned to both stay within ecological and social limits and to avoid technocracy."[130]
- Martin W. Louis (1992)

Small is beautiful – "E.F. Schumacher and his followers believe that expansive social entities are invariably governed by stifling bureaucracies whole rule-bound behaviors lead to environmental degradation and social waste." Schumacharians believe "true human values can only be realized in intimate groups", and that the "wisdom of small scale organization is mirrored in ecological systems, themselves structured around local transfers of energy and matter."[131]
- Martin W. Louis (1992)

The Six Competing Logics of Sustainable Architecture[132] –

Logic	Image of Space	Source of Environmental Knowledge	Building Image	Technologies	Idealized Concept of Place
Eco-technic	global context macrophysical	technorational scientific	commercial modern future oriented	integrated energy efficient high-tech intelligent	Integration of global environmental concerns into conventional building design strategies. Urban vision of the compact and dense city.
Eco-centric	fragile microbiotic	systemic ecology metaphysical holism	polluter parasitic consumer	autonomous renewable recycled intermediate	Harmony with nature through decentralized, autonomous buildings with limited ecological footprints. Ensuring the stability, integrity, and "flourishing" of local and global biodiversity.
Eco-aesthetic	alienating anthropocentric	sensual postmodern science	iconic architectural New Age	pragmatic new nonlinear organic	Universally reconstructed in the light of new ecological knowledge and transforming our consciousness of nature.
Eco-cultural	cultural context regional	phenomenology cultural ecology	authentic harmonious typological	local low-tech commonplace vernacular	Learning to "dwell" through buildings adapted to local and bioregional physical and cultural characteristics.
Eco-medical	polluted hazardous	medical clinical ecology	healthy living caring	passive nontoxic natural tactile	A natural and tactile environment which ensures the health, well-being, and quality of life for individuals.
Eco-social	social context hierarchical	sociology social ecology	democratic home individual	flexible participatory appropriate locally managed	Reconciliation of individuals and community in socially cohesive manner through decentralized "organic," nonhierarchical, and participatory communities.

- Guy, Simon, and Graham Farmer (2001)

Sustainable Area Budget – "If issues of equity and human rights are to be respected, every individual is entitled to his/her share of the earths bounty on a regenerative basis that is, within its capacity to absorb offences. We have developed this concept as a Sustainable Area Budget (SAB). This metric of sustainability means that each individual is entitled to one six billionth of the earth's regenerative capacity interpreted as land area. A town's or city's working budget is thus the aggregated SAB of its citizens."[133]
- Richard S. Levine (2003)

Sustainable Growth – Brundtland, `calls for "a new era of economic growth – growth that is forceful and at the same time socially and environmentally sustainable"[134]
- World Commission on Environment and Development (1987)

Sustainable Growth: An Impossibility Theorem – Impossibility statements are the very foundation of science. It is impossible to: travel faster than the speed of light; create or destroy matter-energy; build a perpetual motion machine, etc. By respecting impossibility theorems we avoid wasting resources on projects that are bound to fail. Therefore economists should be very interested in impossibility theorems, especially the one to be demonstrated here, namely that it is impossible for the world economy to grow its way out of poverty and environmental degradation. In other words, sustainable growth is impossible. In its physical dimension the economy is an open subsystem of the earth ecosystem, which is finite, nongrowing, and materially closed. As the economic subsystem grows it incorporates an ever greater proportion of the total ecosystem into itself and must reach a limit at 100 percent, if not before. Therefore its growth is not sustainable. The term "sustainable growth" when applied to the economy is a bad oxymoron—self-contradictory as prose, and invocative as poetry.[135]
- Herman E. Daly and Kenneth N. Townsend (1993)

Sustainable Growth versus Sustainable Development – "Daly and Cobb have… defin[ed] 'growth' as 'quantitative expansion in the scale of physical dimensions of the economic system,' while defining 'development' as 'qualitative chance of a physically nongrowing economic system in dynamic equilibrium with the environment.' As they argue, 'by this definition,

the earth is not growing but developing. Any physical sub-system of a finite and nongrowing earth must, itself, also eventually become nongrowing. Therefore, growth will become unsustainable eventually and the term "sustainable growth" would then become self contradictory. But, sustainable development does not become self-contradictory.'"[136]
- Ernest J. Yanarella and Richard Levine (1992)

Develop – "to bring out the capabilities or possibilities of, to bring to a more advanced or effective state"[137]
- Random House Dictionary of the English Language (1987)

Ecodevelopment – "development at regional and local levels … consistent with the potentials for the area involved, with attention given to the adequate and rational use of the natural resources, and to applications of technological styles" – (UNEP 1975) a regional focus for resource planning, informed by technological considerations[138]
- Michael Redclift (1987)

Oikonomia –"Daly and Cobb have attacked the misplaced concreteness and 'disciplinolatry' of contemporary economics, arguing that neo-classical economic theory even in its modern guises misrepresents the individual, rational behaviour, the market, land, and economic success by a variety of means of theoretical abstraction and conceptual reification. In questioning these renderings of fundamental concepts in this discipline, they seek to reformulate its conceptual bases in a manner that relocates *homo economicu*s as a real person existing within a web of concrete, social, political and ecological relationships. In rendering the real socio-historical person as the intersecting point of a wide variety of relationships, they, then develop an alternative economic model that gives moral priority to human communities within wider communities existing over time and tying present generations to a view of the economy as *oikonomia*, to responsibilities to future generations, and to the continuing health of the biosphere."[139]
- Ernest J. Yanarella and Richard Levine (1992)

Sustainable Development –"A sustainable society would be interested in qualitative development, not physical expansion. It would use material growth as a considered tool, not as a perpetual mandate. It would be neither for, nor against, growth, rather it would begin to discriminate kinds of growth and purposes for growth. Before this society would decide on any specific growth proposal, it would as what the growth was for, and who would benefit, and what it would cost, and how long it would last, and whether it could be accommodated by the sources and sinks of the planet."[140]
- Donella H. Meadows et al. (1992)

Infinite versus Zero Growth – "All those who had helped to shatter the myth of growth…were ridiculed and figuratively hanged, drawn, and quartered by the loyal defenders of the sacred cow of growth. Some of those…accused the [*Limits to Growth*] report… of advocating ZERO GROWTH. Clearly, such people have not understood anything, either about the Club of Rome, or about growth. The notion of zero growth is so primitive – as, for that matter, is that of infinite growth – and so imprecise, that it is conceptual nonsense to talk of it in a living, dynamic society."[141]
- Aurelio Peccei (1977)

Growth and Development in Complex Ecosystems – "Michael Redclift…has shown how complex ecosystems, like tropical rainforests, achieve homeostatic balance, or what natural ecologists call 'climax systems' of high diversity, large biomass, and high stability through protection from rapid change and 'through shifts of energy flows, away from production, and towards the maintenance of the system itself.' By contrast, he notes, human settlements typically seek to stall such ecosystems in early stages of ecological succession,, where the yield of products is high, but where the stabilizing elements of organic matter and biomass fail to accumulate. High production within these ecosystems, then, comes at the 'cost of confounding nature's strategy of maximum protection or adaptation'"[142]
- Ernest J. Yanarella and Richard Levine (1992)

Substitutability – "Under this view, there should be no concern with using up a nonrenewable natural resource because some other resource can theoretically be substituted. In practice, however, substitution can be difficult and may have significant economic costs. When an economy and infrastructure are built around certain resources, like our transportation systems are built around the use of liquid petroleum fuels, the dollar costs of shifting to an alternate resource affect the feasibility of change. Also, our economy relies on the natural world not only for extractable natural resources but also for *ecosystem services* such as cycling of nutrients, decomposition of wastes, or purification of air and water. Substitution may not even be a remote possibility for these services. [143]

Human Exceptionalist School – "When we use resources, then, we ought to ask whether our present use is at the expense of future generations. The answer is a straightforward *no*. If the relative prices of natural resources can be expected to be lower for future generations than for us now – and this seems to be a reasonable expectation for most natural resources … -- this implies that future generations will be faced by no greater economic scarcity than we are, but instead we'll have just as large or larger supplies of resources to tap, despite our present use of them. Hence, our present use of resources, considered in sum, has little if any negative effect upon future generations. And our descendants may well be better off if we use the resources in question right now to build a higher standard of living. So we need make no ethical judgments for our descendants." "Because we can expect future generations to be richer than we are, no matter what we do about resources, asking us to refrain from using resources now so that future generations can have them later is like asking the poor to make gifts to the rich." "Nor is conservation by the rich good for the poor, domestically or internationally. What the poor need is economic growth. And 'economic growth means *using* the world's resources of minerals, fuels, capital, manpower and land. There can be no return to Walden Pond without mass poverty.'"[144]
- Julian Simon (1981)

Weak Sustainability versus Strong Sustainability – "Weak sustainability allows the substitution of equivalent human-made capital for depleted natural capital. From this perspective, the loss of the income-earning potential of a former forest is no problem if part of the proceeds of liquidation have been invested in factories of equivalent income-earning potential. By contrast, 'strong sustainability' recognizes the unaccounted ecological services and life-support functions performed by many forms of natural capital and the considerable risk associated with their irreversible loss. (In addition to wood fibre, forests provide flood and erosion control, heat distribution, climate regulation, and a variety of other non-market functions and values.) Strong sustainability therefore requires that natural capital stocks be held constant independently of human-made capital."[145]
- Wackernagel, Mathis, and William Rees (1996)

Strong Sustainability – "So far there does not exist a comprehensive empirical study measuring SS [Strong Sustainability]."[146]
- Eric Neumayer (1999)

4. OPERATIONAL DEFINITION OF SUSTAINABILITY (PRESCRIPTIVE)

A growing consensus is emerging regarding many of the principles and attributes of the future sustainable city. However, as illustrated in this Thesaurus, most researchers have not come to grips with identifying or conceptualizing operational methods and models for getting from here to there. Drawing upon the examples of cultural and environmental "proto-sustainability" found in historic and traditional settlements, the Center for Sustainable Cities has appropriated the insights and perspectives of the Greek polis, the medieval Italian hilltown, and, most recently, the traditional Chinese village as proto-sustainability models. Urban, architectural, economic, and ecological imbalances were dynamically rebalanced in these settlements through the self-adjusting process of just trying to live in a comfortable way. Although the social and political dimensions of these historic polities often left much to be desired, these communities have led the Center to conclude that the city and its supporting region is the smallest scale at which the issues of sustainability can effectively be negotiated and the largest scale at which it is currently feasible to do so in our modern globalized society.

After having reached this conclusion, the Center sought to articulate its understanding in a series of governing rules called the "Five Operating Principles of Sustainability" (see below). The Center was later called upon to integrate these principles as the philosophical basis of the European Charter of Cities and Towns Towards Sustainability (1994). This document, more commonly known as the Aalborg Charter[147] after the conference venue where the Charter was negotiated and ratified, has become the principle vehicle in Europe for the implementation of the Local Agenda 21 provisions of the Rio de Janiero Earth Summit of 1992 and has subsequently been ratified by over 1000 European cities. A further development of these principles that resulted from a collaboration between the Center for Sustainable Cities and Oikodrom, the Vienna Institute for Urban Sustainability, presents this complete, coherent, operational definition:

> Sustainability is a local, informed, participatory, balance-seeking process, operating within a Sustainable Area Budget, exporting no harmful imbalances beyond its territory or into the future, thus opening the spaces of opportunity and possibility.[148]

This definition employs the Sustainable Area Budget to offer for the first time a metric of sustainability embedded in an operational process that can allow for the implementation of sustainability projects. The definition formulates the Sustainable Area Budget as a means of defining the sustainability datum of a city-region and describes a kind of balance-seeking game—what the Center has termed the Sustainable City Game—that can come into play. Unlike most current decision-making processes which, because of competing interests, become highly charged power struggles that focus on single issues without taking into account the sustainability of the whole system, the Sustainable City Game is a non-threatening concept through which a sustainable decision making process can be initiated. Engaged in the Game, the citizen-stakeholders of a given city-region negotiate amongst themselves how they can afford to live within the limits of their land budget limited only by their own culture and creativity.

The Sustainable City Game begins by encouraging players to place any legitimate needs and ideas on the table. Then, varied teams of stakeholders—together with designers, social scientists, natural scientists, and other professionals—attempt to assemble a number of different design scenarios that represent these competing interests. These design scenarios would all be negotiated within the Sustainable Area Budget of the city. Thus, the design and development of the city becomes an empowerment process, engaging citizen-stakeholders in the shaping of their common, sustainable future. These scenarios are then modeled as both physical designs and energy and material flow models using the Sustainability Engine™, a utility still under development that combines some of the attributes of intelligent CAD, facilities management and GIS software together with systems dynamics modeling software to become the principal feedback, design and management tool in the negotiation of sustainable city-regions.[149]

The practice of architecture in recent years has increasingly gravitated toward the delivery of contract documents in intelligent CAD and/or facilities management formats. Through embedded databases these formats provide the capability of extracting many sorts of useful information about the virtual building. Material takeoffs of virtually every nut and bolt together with their locations and specifications are easily charted. Maintenance and replacement schedules can be developed and recorded. Changes made in material, size and energy performance are automatically projected through the building model and its database and the reverberations of those changes can be instantly displayed. It is a small conceptual step from the design and management of conventional buildings to the design and management of sustainable cities. One difference is that in the case of sustainable cities, much more information is attached to the components, systems and building blocks that make up the city model. Within the memory storage of the Sustainability Engine™ will be module libraries of components and building blocks containing myriad attributes—including such things as embodied energy, distance from source, cost, availability within the SAB, labor requirements, recyclability, land use implications, energy and material flow connections to other regenerative systems, and the various inputs and outputs involved in the functioning of the module within the city-system. These modules function as plug-in, "free body" objects that provide inputs and outputs when attached to a larger

city-system scenario model.[150]

In the playing of the Sustainable City Game, stakeholders together with architects and scientists attempt to assemble a sustainable city model, drawing on the existing building blocks from the Sustainability Engine™ that most closely meet their needs and desires. If no building blocks are suitable, existing blocks are modified or the architects develop completely new ones that respond to the local architectural vernacular, particular site conditions, material availability, the local technical know-how, and the desires of the stakeholders. Because any urban design that represents the needs or interests of only one stakeholder or group of stakeholders will not contain the diversity or complexity of a real town, such a limited model when run on the Sustainability Engine™ will appear in its first trial run as a city-system that is grossly out of balance. The feedback of this imbalance becomes an important moment for the stakeholder-players. It indicates to them that in spite of the fact that their immediate needs may have been well satisfied by their preferred urban proposal, because their interests represent only a portion of the city-system, many other needs must be met in order for the city-system to be approaching equilibrium. This feedback then supports a significant operational principal of the sustainability endeavor: any proposition may be put on the table, but in order to be carried forward in subsequent iterations of the Game, the overall city-system scenario in which the proposition is embedded must be approaching equilibrium. Very quickly it is seen that no matter how beneficial a given proposition may appear (or however politically powerful its proponent), it must still attach itself to a more extensive network of mutually supportive propositions to form a larger, well-balanced, synergistic scenario in order to remain viable as the Game progresses.[151]

The Game is played through many iterations and at each successive step the scenarios become more sophisticated and more complex. In a similar fashion, the Game itself and its module libraries take the form of learning ecologies through repeated game-playing, becoming more elaborated and accumulating more options and being able to provide more sophisticated feedback. Because of its growing successes the Game and the city models its playing generates, become attractors of people and interests who are in a position to act upon what they have negotiated to be their preferred form and structure of a locally determined sustainable city. As the game becomes sufficiently serious that construction is planned and carried out and people come to live in the city, the same stakeholder process that generated the city form and structure using the Sustainability Engine™ continues to be employed as the process by which the city advances its development, modification, maintenance and governance.[152]

The City-as-a-Hill is a concept first developed by the Center for Sustainable Cities and Oikodrom as an urban implantation to be built over the Westbahnhof railroad yard in Vienna.[153] This is the sort of new urban model that is particularly well suited for use with the Sustainable City Game. Originally inspired by the dense human-scaled urban fabric of medieval Italian hilltowns, the new model also provides for a walkable pedestrian scale, which requires few vehicles, and allows for public space such as markets and squares. Whereas its medieval counterpart was a city built *on* a hill, the new urban model becomes a city built *as* a hill, with the inner "hill" being comprised of the many large-scale industrial buildings, mass transportation and other necessary infrastructure that is needed for the operation of a modern city. The sustainable City-as-a-Hill would be surrounded by a large agricultural hinterland corresponding to its population-based Sustainable Area Budget that would supply all of the land-based resources necessary to support its industry and way of life. The construction of the "hill" is made possible by a flexible structural system, the Coupled Pan Space Frame, a post-tensioned concrete structure developed by Richard S. Levine at the University of Kentucky. This space frame spans large distances and at the same time allows for systems infrastructure to be interwoven within the depth of the structure. The space frame system also easily accommodates future expansion and modification of the city, allowing the surface to evolve and increase in complexity over time.

In conclusion, through synthesizing scientific tools with design and participatory methods, the sustainability process described above seeks to avoid the narrow determinism of specialized scientific disciplines and the various tools for the implementation of sustainability and, in so doing, demonstrate a rich and complex means of accommodating diverse and conflicting interests to create a Sustainable Civil Society form of governance.[154] As the first sustainable city emerges out of this process, its success will provide the momentum and enthusiasm for the building of additional sustainable cities, each with different activities and industries and therefore, different urban and architectural design. A network of such cities could be linked together to form a regional cooperative of synergistic sustainable settlements. In this way, sustainability could be exported to the world.

Five Operating Principles of Sustainability

"First Operating Principle: Individual and discrete program of sustainable development do not necessarily lead to ecological or social sustainability.

Second Operating Principle (the principle of homeostatic balance): A desire activity or process can take its place in a larger system only by finding its balances with that more encompassing system.

Third Operating Principle (the principle of chaotic excess or extravagance): No natural process or social system can avert the action or intervention of those forces of chaos or disorder in the cosmos because they are always already there.

Fourth Operating Principle: All system shall first be designed to seek their ecological balances, at the smallest scale, but in any event at no scale larger than the city/region itself.

Fifth Operating Principle: all lower imbalances are to be negotiated outward."[155]
- Earnest J. Yanarella and Richard S. Levine (1992)

Operational Definition of Sustainability – "Sustainability is a local, informed, participatory balance-seeking process, operating within a Sustainable Area Budget, exporting no harmful imbalances beyond its territory or into the future, thus opening the spaces of opportunity and possibility."[156]
- Heidi Dumreicher, Richard S. Levine, Ernest J. Yanarella (2000)

"Sustainability is a local...: Sustainability needs a place to happen. Although problems aggregate and become manifest on a global scale (e.g., ozone depletion, global climate change), offenses to the environment are produced locally. When dealt with locally, where "local" means the city/region, the neutralization or reuse of all negative byproducts must be considered part of the price of doing business. The earlier history of our civilization is the history of city/regions--largely autonomous towns that gained virtually all of their material needs from their local countryside and had to maintain the quality of the countryside in order to sustain their way of life. From this perspective, sustainability can only happen at the scale of the city/region--the largest scale capable of addressing the many urban architectural, social, economic, political and other imbalances besetting the modem world and simultaneously the smallest scale at which such problems can be meaningfully resolved in an integrated and holistic fashion.

… informed...:In order to be able to maintain the quality and the productivity of the local region and its countryside one must understand the consequences of the metabolic activities occurring within the city/region. Earlier towns operating within a largely closed system received rather rapid feedback as to the consequences of their activities. Because almost all activities manifested locally, causes and effects related to those activities were quickly understood. When imbalances threatened the city/system, they were noted and adjusted locally. In the modem world there are effectively no local boundaries and positive activities at a small scale may well have negative consequences at larger scales. By using modern means, however, we gain powerful tools both to design and monitor major energy and material flows and to model the projected implications of different processes we might choose to include in our city/region.

…participatory...: Sustainability is a process by which a local community can decide how it will afford to live within its natural budget and the limits of its own creativity. Such a process starts with the principle that sustainability is nonnegotiable, where in principle everything else is negotiable. That means that all participants in the process must agree that the health, equity and viability of the city/system is the precondition for any other decision. Secondly, as the sustainability process proceeds, stakeholders increasingly realize that they share a common destiny and that significant synergies will result from their creative encounters and negotiations. Through many iterations, the city/region becomes understood more as an urban ecosystem and less as adversarial, zero-sum game. Eventually, the players become partners and more focused on building common wealth.

… balance-seeking process...: The problem with our existing economic system is that it has no built-in mechanism to insure its own long-term survival. It is not designed to pursue balance. As noted above, natural ecosystems in early stages of succession are also designed to maximize production at low levels of diversity, but as such systems mature, and organic material accumulates, the emphasis shifts away from production and toward maximizing diversity, resiliency and maintaining internal balances. This needs to be the model for human ecosystems.

… operating within a Sustainable Area Budget (SAB) ... : In the past, nature was assumed to be so vast as to be able to comfortably absorb any and all offenses that humankind's activities dumped onto it. It is now clear that we have long since exceeded many of nature's capacities. The Sustainable Area Budget is our concept for the natural budget in land area, available for each city/region to support its way of life. A simple determination of the SAB for a city/region goes something like this: simply divide a country's total land area by its population and multiply by the number of people in the city/region.

… exporting no harmful imbalances beyond its territory or into the future: The key idea here is that when the prior part of this definition is realized such a city/region will effectively export no problems beyond its territory or into the future. On the other hand, even this circumstance is negotiable, given our Fifth Operating Principle for Sustainable Cities, which states that "imbalances are to be negotiated outward." This means that in some cases an imbalance may be exported from the city/region, but only if its rebalancing can be accounted for by an agency beyond the scale of the city/region.

… thus opening the spaces of opportunity and possibility: such a process is seen as an empowering and liberating activity that maximizes the principle of locally bounded informed choice within globally recognized limits." [157]
- Heidi Dumreicher, Richard S. Levine, Earnest J. Yanarella (2000)

[1] *Webster's New International Dictiona*ry (1986). Springfield, Mass.: Merriam-Webster Inc.
[2] The World Commission on Environment and Development (WCED) (1987), *Our Common Future*. Oxford: Oxford University Press,p. 43.
[3] WCED (1987)
[4] http://www.ssne.org. (Retrieved Jul. 31, 2005)
[5] http://www.sustainable.doe.gov/overview/definitions.shtml (Retrieved Jul. 31, 2005)
[6] http://www.thecornucopia.org/ecology/ecobldg/ecobldg.htm (Retrieved Jul. 31, 2005)
[7] Sachs, Wolfgang et al. (1998). *Greening the North: A Post Industrial Blueprint for Ecology and Equity*. London: Zed Books, p. 15.
[8] Levine, Richard S., Ernest Yanarella and Heidi Dumreicher (1994). "A Complete Local Agenda 21 Process: The Appropriate Relationship of People, Design, and Science."
[9] Leopold, Aldo (1966). *A Sand County Almanac*. New York: Balantine, p. 240.
[10] http://www.olywa.net/roundtable (Retrieved Jul. 31, 2005)
[11] http://www.unity.edu/sustainability/Sustainability.htm (Retrieved Jul. 31, 2005)
[12] http://www.indiana.edu/~workshop/papers/chakrabarti022502.pdf (Retrieved Jul. 31, 2005)
[13] http://www.emrgnc.com.au/Sustainability%20Definitions.pdf (Retrieved Jul. 31, 2005)
[14] *Coop America Quarterly*, No. 37 Summer 1995
[15] The World Conservation Union (IUCN), United Nations Environment Programme (UNEP), and World Wide Fund for Nature (WWF, *Caring for the Earth: A Strategy for Sustainable Living*, (Gland, Switzerland: 1991).
[16] http://www.context.org/ICLIB/DEFS/AIADef.htm (Retrieved Jul. 31, 2005)
[17] Norton, B.G. (1992). "A New Paradigm for Environmental Management." in Costanza, R., Haskell B.D., Norton, B.G., eds. (1992) *Ecosystem Health: New Goals for Environmental Management.* Island Press, Washington, DC, p. 23-41.
[18] http://www.ssne.org/ (Retrieved Jul. 31, 2005)
[19] Ruckelshaus, William D. "Toward a Sustainable World", *Scientific American*, September 1989.
[20] Hawken, Paul. (1993), *The Ecology of Commerce.* New York: HarperBusiness, p. 139.
[21] Daly, Herman E. (1996). *Beyond Growth*. Boston: Beacon Press, p. 31.
[22] Daly, Herman E. (1977). *Steady-State Economics*, San Francisco: W. H. Freeman, p. 17.
[23] http://www.naturalstep.org/learn/principles.php (Retrieved Jul. 31, 2005)
[24] Martin, Muscoe. "A Sustainable Community Profile" *Places*, 1995.
[25] Lélé, Sharachchandra. M. (1991). "Sustainable Development : A Critical Review," *World Development*, Vol 19, No.6
[26] http://www.wbcsd.ch (Retrieved Jul. 31, 2005)
[27] Robinson, John and Caroline Van Bers (1996). *Living Within Our Means: The Foundations of Sustainability*. Vancouver, BC: David Suzuki Foundation, p. iii.
[28] Annan, Kofi. "From Doha to Johannesburg by way of Monterrey: How to achieve sustainable development in the 21st century". London, Feb 2002.
[29] Meadows, Donella H. and Dennis L. and Jørgen Randers (1992) *Beyond the Limits: Confronting Global Collapse, Envisioning a Sustainable Future*, Post Mills, Vermont: Chelsea Green Publishing Company, p. 209.
[30] Lachman, Beth E. "Linking Sustainable Community Activities to Pollution Prevention: A Sourcebook," April 1997.
[31] Plato (360 B.C.). *Laws*. Quoted in Wackernagel, Mathis, and William Rees (1996). *Our Ecological Footprint: Reducing Human Impact on the Earth.* Gabriola Island, B.C.: New Society Publishers, p. 48.
[32] Malthus, Thomas (1798), *An Essay on the Principle of Population, as it Affects the Future Improvement of Society with Remarks on the Speculations of Mr. Godwin, M. Condorcet, and Other Writers.* London: as summarized on http://en.wikipedia.org/wiki/Overpopulation#Malthus.27s_theory (Retrieved Jul. 31, 2005)
[33] Ehrlich, Paul R. and Anne H. Ehrlich (1990). *The Population Explosion*. New York, NY, Simon and Schuster, p. 17.
[34] Daily, Gretchen C. and Paul R. Ehrlich (1992). "Population, sustainability, and Earth's carrying capacity." *Bioscience* 42(10):761-771.
[35] Ophuls, William and A. Stephen Boyan, Jr. (1992). *Ecology and the Politics of Scarcity Revisited: The Unraveling of the American Dream.* New York: W. H. Freeman and Co., p. 272-273.
[36] Wackernagel, Mathis, and William Rees (1996). *Our Ecological Footprint: Reducing Human Impact on the Earth*. Gabriola Island, B.C.: New Society Publishers, as summarized on http://www.sustaindane.org/main/EF2.htm (Retrieved Jul. 31, 2005)

[37] Wackernagel, Mathis, and William Rees (1996), p. 9.
[38] Sachs, Wolfgang et al. (1998), Greening the North: A Post Industrial Blueprint for Ecology and Equity, London: Zed Books, p. 12.
[39] Wackernagel, Mathis, and William Rees (1996), p. 158.
[40] Narodoslawsky, M., C. Krotscheck "Integrated Ecological Optimization of Processes with the Sustainable Process Index," http://www.dcs.vein.hu/pres/naro.html (Retrieved Jul. 31, 2005)
[41] Levine, Richard S., Michael Hughes, and Casey Ryan Mather (2005). "Designing the Future Sustainable City: Projecting Sustainability from Seven Villages in China," The 22nd Conference on Passive and Low Energy Architecture. Beirut, Lebanon, 13-16 November 2005
[42] Vitousek, Peter., Paul.R. Ehrlich, Anne. H. Ehrlich, and Pamela .A. Matson (1986). "Human Appropriation of the Products of Photosynthesis." *Bioscience* 36(6): 368-373.
[43] Hardin, Garrett. "The Tragedy of the Commons," *Science*, 162(1968):1243-1248 as summarized on http://en.wikipedia.org/wiki/Tragedy_of_the_commons (Retrieved Jul. 31, 2005)
[44] Hardin, Garrett (1974). "Living on a Lifeboat" *BioScience*, vol 24(10), p. 561-568.
[45] Hardin, Garrett (1974)
[46] Cutter, Susan L. and William H. Renwick (1999). *Exploitation, Conservation, Preservation: A Geographic Perspective on Natural Resource Use*, third ed. New York: Wiley
[47] http://www.attra.org/attra-pub/perma.html#defined (Retrieved Jul. 31, 2005)
[48] http://www.ftai.com/aquaculture.htm (Retrieved Jul. 31, 2005)
[49] http://www.fao.org/organicag/fram11-e.htm (Retrieved Jul. 31, 2005)
[50] Lovins, Amory B. (1977) *Soft Energy* Paths*: Toward a Durable Peace.* San Fransisco: Friends of the Earth International. As summarized by Daly, Herman E. and John B. Cobb Jr. (1989) *For the Common Good: Redirecting the Economy toward Community, Environment, and a Sustainable Future*, Boston: Beacon Press, p. 261-262.
[51] http://en.wikipedia.org/wiki/Bioenergy (Retrieved Jul. 31, 2005)
[52] http://www.suscon.org/dairies/methanedigesters.asp (Retrieved Jul. 31, 2005)
[53] http://en.wikipedia.org/wiki/Tidal_power (Retrieved Jul. 31, 2005)
[54] http://www.eeexchange.org/sustainability/content/f3.html (Retrieved Jul. 31, 2005)
[55] Graedel, Thomas E. and Braden R. Allenby (1995). *Industrial Ecology.* Englewood Cliffs, New Jersey: Prentice Hall, as summarized on http://www.eeexchange.org/sustainability/content/f3.html (Retrieved Jul. 31, 2005)
[56] Sachs, Wolfgang et al. (1998). *Greening the North: A Post Industrial Blueprint for Ecology and Equity.* London: Zed Books, p. 104
[57]Smith, Ronald S., Jr. (1998). *Profit Centers in Industrial Ecology: The Business Executive's Approach to the Environment.* Westport, Connecticut: Quorum Books. as summarized on http://www.eeexchange.org/sustainability/content/f3.html (Retrieved Jul. 31, 2005)
[58] Lowe, Ernest A., John L. Warren, and Stephen R. Moran (1997). *Discovering Industrial Ecology: An Executive Briefing and Sourcebook.* Columbus, Ohio: Battelle Press. as summarized on http://www.eeexchange.org/sustainability/content/f3.html (Retrieved Jul. 31, 2005)
[59] http://www.eeexchange.org/sustainability/content/f3.html (Retrieved Jul. 31, 2005)
[60] Adriaanse, Albert, S. Bringezu, A. Hammond, Y. Moriguchi, E. Rodenburg, D. Rogich, H. Schutz. 1997. *Resource Flows: The Material Basis of Industrial Economies.* World Resources Institute, Washington, DC. As summarized on http://www.eeexchange.org/sustainability/content/f3.html (Retrieved Jul. 31, 2005)
[61] McDonough, William and Michael Braungart. "The Next Industrial Revolution." The Atlantic Monthly Oct. 1998
[62] The International Forum on Globalization (2002), p.191.
[63] http://www.indigodev.com/IE.html (Retrieved Jul. 31, 2005)
[64] http://www.worldenergy.org/wec-geis/publications/default/tech_papers/17th_congress/2_2_17.asp#Heading4
[65] McDonough, William and Michael Braungart.(1998). The Next Industrial Revolution. *The Atlantic Monthly*
[66] Dumreicher, Heidi, Richard S. Levine, Ernest J. Yanarella, and Taghi Radmard. (2000). "Generating Urban Models of Urban Sustainability: Vienna's Westbahnhof Sustainable Hill Town." In Katie Williams, Elizabeth Burton, and Mike Jenks *Achieving Sustainable Urban Form.* New York: E & FN Spon (Rouledge).
[67] http://en.wikipedia.org/wiki/Passive_solar (Retrieved Jul. 31, 2005)
[68] http://en.wikipedia.org/wiki/Evaporative_cooling (Retrieved Jul. 31, 2005)
[69] Levine, Richard et al. (2005)

[70] Levine, Richard et al. (2005)
[71] Levine, Richard et al. (2005)
[72] McDonough, William (1992). *The Hannover Principles: Design for Sustainability*. William McDonough Architects.
[73] http://www.mtn.org/iasa/expsustdesign.html#bibliography (Retrieved Jul. 31, 2005)
[74] Daly, Herman E. and John B. Cobb Jr. (1989). *For the Common Good: Redirecting the Economy toward Community, Environment, and a Sustainable Future.* Boston: Beacon Press, p. 265.
[75] Hynes, H. Patricia. (1996). *A Patch of Eden: America's Inner City Gardeners.* White River Junction, VT: Chelsea Green Publishers, and Smit, Jac and Joe Nasr. (1999). "Agriculture: Urban Agriculture for Sustainable Cities: Using Wastes and Idle Land and Water Bodies as Resources." p. 221-233 in Satterthwait, David ed. *The Earthscan Reader in Sustainable Cities.* London: Earthscan Publications. Reprinted from 1992 Environment and Urbanization 4(2):141-152. As summarized on http://www.eeexchange.org/sustainability/content/f3.html (Retrieved Jul. 31, 2005)
[76] The International Forum on Globalization (2002), *Alternatives to Economic Globalization,* Berrett-Koehler Publishers, Inc., p.185-187.
[77] Dumreicher, Heidi and Bettina Kolb (2005). "The Definition of Sustainability in the View of Social Science: Seven Chinese Villages and Their Potential for a Sustainable Future." The 22nd Conference on Passive and Low Energy Architecture. Beirut, Lebanon, 13-16 November 2005.
[78] Dumreicher/Kolb, "Seven theses on town and city quality," in: Benzing, Brigitta and Bernd Herrmann eds. (2003). *Exploitation and Overexploitation in Societies Past and Present*. Münster: LIT
[79] http://www.bowlingalone.com/socialcapital.php3 (Retrieved Jul. 31, 2005)
[80] Dumreicher, Heidi and Bettina Kolb (2005)
[81] Dumreicher, Heidi and Bettina Kolb (2005)
[82] Dumreicher, Heidi and Bettina Kolb (2003)
[83] http://www.lse.ac.uk/collections/CCS/what_is_civil_society.htm (Retrieved Jul. 31, 2005)
[84] Daly, Herman E. (1977). *Steady-State Economics,* San Francisco: W. H. Freeman, p. 17.
[85] Henderson, Hazel (1999). *Beyond Globalization: Shaping a Sustainable Global Economy,* Kumarian Press.
[86] Ekins, Paul (2000). *Economic Growth and Environmental Sustainability: The Prospects for Green Growth.* New York: Routledge, p. 105
[87] Schumacher, E.F. (1973). *Small is Beautiful: A Study of Economics as if People Mattered.* London: Blond & Briggs, p. 12, 14.
[88] Ekins, Paul and Manfred Max-Neef, eds. (1992). *Real-Life Economics: Understanding Wealth Creation.* New York: Routledge. As summarized on http://www.eeexchange.org/sustainability/content/f3.html (Retrieved Jul. 31, 2005)
[89] http://www.eeexchange.org/sustainability/content/f3.html (Retrieved Jul. 31, 2005)
[90] http://www.eeexchange.org/sustainability/content/f3.html (Retrieved Jul. 31, 2005)
[91] http://www.eeexchange.org/sustainability/content/f3.html (Retrieved Jul. 31, 2005)
[92] Stahel, Walter R. (1994). "The utilization-focused service economy: resource efficiency and product-life extension." in Braden R. Allenby and Deanna J. Richards, eds. *The Greening of Industrial Ecosystems.* Washington, DC.: National Academy of Engineering / National Academy Press, p. 178-190
[93] The International Forum on Globalization (2002), p.185-187.
[94] The International Forum on Globalization (2002), *Alternatives to Economic Globalization,* Berrett-Koehler Publishers, Inc., p. 107.
[95] The International Forum on Globalization (2002), p.76.
[96] Ruckelshaus, William D. "Toward a Sustainable World," *Scientific American* (September 1989): p. 167
[97] Henderson, Hazel (1981). *The Politics of the Solar Age: Alternatives to Economics,* Anchor Press/Doubleday
[98] http://en.wikipedia.org/wiki/Systems_thinking (Retrieved Jul. 31, 2005)
[99] Levine, Richard et al. (2005)
[100] http://www.eeexchange.org/sustainability/content/c5.html (Retrieved Jul. 31, 2005)
[101] http://www.usgbc.org/DisplayPage.aspx?CategoryID=19 (Retrieved Jul. 31, 2005)
[102] Metcalf, Gilbert (1998). *A Distributional Analysis of an Environmental Tax Shift.* San Francisco: Redefining Progress.
[103]William Ophuls (1978). *Ecology and the Politics of Scarcity: Prologue to a Political Theory of the Steady State.* San Francisco: Freeman, p. 221
[104] Ophuls (1978),p. 223

[105] Van Dieren, Wouter ed. (1995). *Taking Nature Into Account: Toward a Sustainable National Income – A Report to the Club of Rome.* New York: Springer-Verlag, p. 97
[106] WCED (1987), p. xii
[107] Silas, C. J., CEO of Phillips Petroleum Co., (1990). In Beder, *Global Spin*, p. 23.
[108] Guy, Simon, and Simon Marvin. 1999. "Understanding Sustainable Cities: Competing Urban Futures." *European Urban and Regional Studies* 6 (3): 268-275.
[109] Yanarella, Ernest J. and Richard S. Levine (2005). "Sustainability and Social Constructivism: An Alternative Sustainable Cities Approach"
[110] Daly, Herman E. and John B. Cobb Jr. (1989), p. 71.
[111] Daly, Herman E. and John B. Cobb Jr. (1989), p. 71.
[112] Redclift, Michael (1987). *Sustainable Development: Exploring the Contradictions*. London: Routledge, Kegan & Paul.
[113] Daly, Herman E. and John B. Cobb Jr. (1989), p. 72.
[114] Neumayer, Eric. (1999) Weak versus Strong Sustainability: Exploring the Limits of Two Opposing Paradigms, London, Edward Elgar Publishing, p. 202.
[115] Levine, Richard S., Ernest J. Yanarella, Heidi Dumreicher, and Tiffany Broyles (2000). "Beyond Sustainability Indicators: The Sustainable Area Budget." Making Sustainable Development Visible: Indicators for Regional Development, Gratz, Austria.
[116] Daly, Herman E. and John B. Cobb Jr. (1989), p. 184.
[117] The International Forum on Globalization (2002), p. 19.
[118] Daly, Herman E. (1977). *Steady-State Economics*. San Francisco: W. H. Freeman
[119] The International Forum on Globalization (2002), p. 24.
[120] Nadeau, Robert L. (2003). *The Wealth of Nature: How Mainstream Economics Has Failed.* New York: Columbia University Press, p. 35.
[121]Boulding, Kenneth E. (1966). "The economics of the coming spaceship earth." in *Environmental Quality in a Growing Economy*. Henry Jarrett, ed. *Resources for the Future*, Baltimore, PA: Johns Hopkins Press, Inc., p. 3-14.
[122]Lovelock, J. E. (1979). *Gaia: A New Look at Life on Earth*. Oxford: Oxford University Press, p. vii.
[123] Meadows, Donella H. and Dennis L. and Jørgen Randers (1992). *Beyond the Limits: Confronting Global Collapse, Envisioning a Sustainable Future*. Post Mills, Vermont: Chelsea Green Publishing Company, p. 128.
[124] Louis, Martin W. (1992). *Green Delusions: An Environmentalist Critique of Radical Environmentalism*, Durham: Duke University Press, p. 42
[125] Louis, Martin W. (1992), p. 27-41.
[126] Louis, Martin W. (1992), p. 253-256.
[127] Louis, Martin W. (1992), p. 253-256.
[128] Devall, Bill and George Sessions (1985). *Deep Ecology: Living as if Nature Mattered.* Layton, UT: Peregrine Smith Books.
[129] Louis, Martin W. (1992), p. 117.
[130] Louis, Martin W. (1992), p. 117.
[131] Louis, Martin W. (1992), p.82.
[132] Guy, Simon, and Graham Farmer (2001). "Reinterpreting Sustainable Architecture: The Place of Technology." *Journal of Architectural Education*. 54 (February): 140-148.
[133] Levine, Richard S., Yanarella E. J., Radmard T., and Dumreicher, H. (2003). "Sustainable Cities: A Strategy for a Post-terrorized World. http://www.terrain.org/articles/13/strategy.htm, (13). (Retrieved Jul. 31, 2005)
[134] WCED (1987), p. xii
[135] Herman E. Daly and Kenneth N. Townsend (1993). *Valuing the Earth: Economics, Ecology, Ethics*. Cambridge, Massachusetts: The MIT Press, p. 267.
[136] Yanarella, Ernest J. and Richard Levine. "Does Sustainable Development Lead to Sustainability?," *Futures* (October 1992), p. 761-762.
[137] Random House Dictionary of the English Language (1987). New York, NY: Random House.
[138] Redclift, Michael (1987), p. 34.
[139] Yanarella, Ernest J. and Richard Levine (1992), p. 768-769.
[140] Meadows, Donella H. et al. (1992), p. 210.
[141] Peccei, Aurelio (1977) *The Human Quality*. Oxford: Pergamon Press, p. 85.

[142] Yanarella, Ernest J. and Richard S. Levine (2005), "Sustainability and Social Constructivism: An Alternative Sustainable Cities Approach"
[143] http://www.eeexchange.org/sustainability/content/f3.html (Retrieved Jul. 31, 2005)
[144] Simon, J. (1981). *The Ultimate Resource*. Princeton, NJ: Princeton University Press, p. 149, 151.
[145] Wackernagel, Mathis, and William Rees (1996), p. 37.
[146] Neumayer, Eric. (1999), p. 202.
[147] The Aalborg Charter, can be accessed online at:
www.aalborg.dk/engelsk/information+about+aalborg/aalborg+charter.htm (Retrieved July, 31 2005)
[148] Dumreicher, Heidi, Richard S. Levine, and Ernest J. Yanarella. (© Oikodrom The Institute for Urban Sustainability, Vienna, Austria and Center for Sustainable Cities, Lexington, KY), 1998-2001
[149] Levine, Richard S. et al. (2003)
[150] Levine, Richard S. et al. (2003)
[151] Levine, Richard S. et al. (2003)
[152] Levine, Richard S. et al. (2003)
[153] Dumreicher, Heidi et al. (2000)
[154] Levine, Richard S. et al. (2005)
[155] Yanarella, Ernest J. and Richard S. Levine (1992)
[156] Dumreicher, Heidi et al. (2000)
[157] Levine, Richard S., Ernest Yanarella, and Heidi Dumreicher, "A Complete Local Agenda 21 Process: The Appropriate Relationship of People, Design, and Science."