What Is a Sustainable City?

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About Richard Heinberg

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Abstract

This Discussion Paper begins by recalling the history of the term *sustainability*, showing how it serves to focus our vital public interest in enhancing our society's long-term prospects for survival and maintenance. The Paper surveys the broad and growing literature on the subject, identifying five "axioms of sustainability," and offers a set of working definitions and criteria that the City of Edmonton can use in its decision-making processes. It also lists some examples of policies and best practices that might help guide the City to avoid pitfalls—in terms of reliance on unreliable and environmentally damaging resource streams—that could otherwise lead to economic and environmental decline. These examples suggest there are many things that Edmonton can do to move in the direction of long-term sustainability while also improving citizens' lives in the short term.

Discussion Paper

The essential meaning of the word *sustainable* is, "able to be maintained over time." We all share a vital public interest in making our society and our city sustainable and in avoiding their failure or collapse.

Unfortunately, the word is widely employed to refer merely to practices that are judged to be marginally more environmentally sound than others. Indeed, *sustainable* is often used so carelessly as to lead some environmentalists to advise abandoning its use.[1] Yet misuse of the word does nothing to diminish its crucial significance.

No human living arrangement can be maintained forever; *sustainability* is a relative term. As a frame of reference it seems reasonable to use the durations of prior civilizations, ranging from hundreds to thousands of years. A sustainable city, then, should maintain itself for many centuries.

Leaders and citizens of most modern cities understandably concern themselves mostly with immediate problems and assume that they will be able to continue solving problems into the distant future. However, history and archaeology provide disturbingly numerous examples showing that short-term thinking can lead to a build-up of social, political, and environmental contradictions that end in calamity.[2]

In this Discussion Paper we will explore the meaning of sustainability in greater depth, examining its history and the conditions required in order for a society or city to maintain itself. I will also discuss why it is important for the City of Edmonton to adopt a clear definition of sustainability, along with meaningful sustainability principles, indicators, and criteria that it can apply to its decisions. I then list some policies that might help the city of Edmonton become more sustainable.

History of Sustainability

The concept of sustainability was embedded in the traditions of many indigenous peoples; for example, it was a precept of the Iroquois *Gayanashagowa*, or Great Law of Peace, that chiefs consider the impact of their decisions on the seventh generation to come.

The first known European use of *sustainability* (German: *Nachhaltigkeit*) occurred in 1712 in the book *Sylvicultura Oeconomica* by German forestry scientist Hannss Carl von Carlowitz, who advised planting trees to avert deforestation.

The term gained widespread usage after 1987, when the Brundtland Report of the World Commission of Environment and Development defined *sustainable development* as action that "meets the needs of the present generation without compromising the ability of future generations to meet their own needs."[3] This definition is still widely used.

Also in the 1980s, Swedish oncologist Dr. Karl-Henrik Robèrt brought together leading scientists to develop a consensus on requirements for a sustainable society. In 1989 he formulated this consensus in four conditions for sustainability, which in turn became the basis for an organization, The Natural Step.[4] Subsequently, many businesses and municipalities around the world pledged to abide by the Natural Step conditions:

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. people are not subject to conditions that systematically undermine their capacity to meet their needs.

Seeing the need for an accounting tool to measure sustainability, Canadian ecologist William Rees and then-graduate student Mathis Wackernagel developed in the early 1990s the concept of the Ecological Footprint, defined as the amount of land and water area a human population would hypothetically need in order to provide the resources required to support itself and to absorb its wastes, given prevailing technology.[5] Implicit in the scheme is the recognition that, for humanity to achieve sustainability, its footprint must be less than the total land/water area of the Earth. In reality, that footprint is currently calculated by the Footprint Network as being about 23 percent larger than the planet can regenerate, indicating that humankind is to this extent over-consuming resources and operating in an unsustainable manner.

Five Axioms of Sustainability

As a contribution to the ongoing refinement of the concept, I have formulated five axioms (self-evident truths) of sustainability.[6] My goal was to distill ideas that had been proposed previously into a form that was concise, easy to understand, and capable of being tested using the methodology of science. Here they are, each followed by a brief discussion:

1. **Any society that continues to use critical resources unsustainably will collapse. (Exception: A society can avoid collapse by finding replacement resources. Limit to the exception: In a finite world, the number of possible replacements is also finite.)**

   This axiom defines sustainability by the consequences of its absence. Jared Diamond's popular book *Collapse: How Societies Choose to Fail or Succeed* argues that collapse is the common destiny of societies that ignore resource constraints.[7] Historically, collapse has meant a precipitous decline in population brought about by social chaos, warfare, disease, or famine.

   A society that uses resources sustainably may still collapse for other reasons beyond the society's control (as a result of an overwhelming natural disaster, or of conquest by another, more aggressive society, to name two possibilities). This first axiom focuses on resource consumption because that is a decisive, quantifiable, and, in principle, controllable determinant of a society's long-term survival.

   The *Exception* and *Limit to the Exception* address the argument that resources are infinitely substitutable, and that therefore modern market-driven societies need never face a depletion-led collapse, even if consumption rates escalate.[8] In some instances, satisfactory substitutes for resources are readily available, as was the case in the mid-19th century when kerosene from petroleum was substituted for whale oil as a fuel for lamps. In other cases, substitutes are inferior, as is the case with oil sands as a substitute for conventional petroleum—since oil sands are less energy-dense, require more energy input for processing, and produce more carbon emissions. As time goes on, societies tend first to exhaust substitutes that are superior and easy to get at, and increasingly have to rely on inferior substitutes to replace depleting resources—unless rates of consumption are held in check.

2. Population growth and/or growth in the rates of consumption of resources cannot be sustained. [9]

Human population growth has been sustained up to the present. How can we be sure that it cannot be sustained into the indefinite future? Simple arithmetic shows that even small rates of growth, if continued, add up to absurdly large—and plainly unsupportable—population sizes and rates of consumption. For example: a one percent rate of growth in the present human population (less than the actual current rate) would result in a doubling of population each 70 years. Thus in 2075, the Earth would be home to 13 billion humans; in 2145, 26 billion; and so on. By the year 3050, there would be one human per square meter of Earth's land surface, including mountains and deserts. Virtually no one expects this to occur: at some point, population growth will cease. Similar calculations apply to consumption rates.

3. To be sustainable, the use of *renewable* resources must proceed at a rate that is less than or equal to the rate of natural replenishment.

Renewable resources are exhaustible. Forests can be over-cut, resulting in barren landscapes and shortages of wood (as occurred in many parts of Europe in past centuries), and fish can be over-harvested, resulting in the extinction or near-extinction of species (as is occurring today globally).

This axiom has been stated in somewhat differing ways by many economists and ecologists, and is the basis for "sustained yield forestry" and "maximum sustainable yield" fishery management.[10]

The first clue that harvesting is proceeding at a rate greater than that of natural replenishment is the decline of the resource base. However, a resource may be declining for reasons other than over-harvesting; for example, a forest not being logged may be decimated by disease. Nevertheless, if the resource is declining, pursuit of sustainability requires that the rate of harvest be reduced, regardless of the cause of decline. Sometimes harvests must drop dramatically, at a rate far greater than the rate of resource decline, so that the resource has time to recover. This has been the case with regard to commercial fish species that have been over-harvested to the point of near-exhaustion, and that have required complete harvest moratoria in order to re-establish themselves—though in cases where the remaining breeding population is too small the species cannot recover.

4. To be sustainable, the use of *non-renewable* resources must proceed at a rate that is declining, and the *rate of decline* must be greater than or equal to the *rate of depletion*. The *rate of depletion* is defined as the amount being extracted and used during a specified time interval (usually a year) as a percentage of the amount left to extract.

Non-renewable resources include fossil fuels and minerals of all kinds. No continuous rate of use of any non-renewable resource is sustainable, unless the resource is completely recycled. However, if the rate of use is declining at a rate greater than or equal to the rate of depletion, this can be said to be a somewhat sustainable situation in that society's dependence on the resource will be reduced to insignificance before the resource is exhausted.[11] For any non-renewable resource the "amount left to extract" is debatable, but prudence dictates adhering to conservative estimates.[12]

5. Sustainability requires that substances introduced into the environment from human activities be minimized and rendered harmless to biosphere functions. *In cases where pollution from the extraction and consumption of resources threatens the viability of ecosystems, reduction in the rates of extraction and consumption of those resources may need to occur at a rate greater than the rate of depletion.*

If axioms 2 through 4 are followed, pollution should be minimized as a result. Nevertheless, these conditions are not sufficient to avert serious impacts.

It is possible for a society to generate pollution from the unwise use of renewable resources; however, the most serious forms of pollution in the modern world arise from the extraction, processing, and consumption of non-renewable resources. If (as specified in Axiom 4) the consumption of non-renewable resources declines, pollution should also decline. However, where the consumption of non-renewable resources has resulted in levels of pollution that threaten basic biosphere functions, heroic measures are called for. This is the situation with regard to atmospheric concentrations of greenhouse gases, especially from the burning of coal and other fossil fuels. Merely to reduce coal consumption by the global coal depletion rate would not suffice to avert a climate catastrophe.

If reduction in pollutants can be obtained without a reduction in consumption of non-renewable resources, for example by using technological means to capture polluting substances and sequester them harmlessly, then a reduction in consumption of such resources need only occur at the depletion rate in order to achieve sustainability.

However, society should be extremely cautious regarding claims for untested technologies' abilities to safely sequester polluting substances for very long periods of time.

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It is essential for cities that want to be sustainable to begin with a clear definition of sustainability and a clear set of sustainability criteria and principles. "Sustainability" is a destination, and unless a city is clear about where that destination is, it will find it very difficult getting there. The following is a summary of definitions and criteria that the City of Edmonton could begin to use in its decisions in order to foster a culture of sustainability:

Definition: *Sustainable*	Able to be maintained over time
Definition: *Sustainable City/Society*	A city/society that can be maintained for many centuries
Definition: *Sustainable Environmental Practices*	Actions or practices that meet the needs (i.e., basic human needs) of the present generation without compromising the ability of future generations to meet their own basic needs
Definition: *Basic human needs*	A comprehensive set of fundamental human needs that are culturally and historically universal, non-overlapping, non-substitutable, complimentary to one another, and must be satisfied on a continual basis. They are: subsistence, protection, affection, idleness, identity, freedom, creativity, participation, and understanding.[13]
Criteria of Sustainability recommended for use by the City of Edmonton:	From The Natural Step Framework • In a sustainable society, nature is not subject to systematically increasing concentrations of substances extracted from the earth's crust. • In a sustainable society, nature is not subject to systematically increasing concentrations of substances produced by society. • In a sustainable society, nature is not subject to

	systematically increasing degradation by physical means. • In that society people are not subject to conditions that systematically undermine their capacity to meet their needs. From "The Five Axioms of Sustainability" • Population growth and/or growth in the rates of consumption of resources cannot be sustained. • To be sustainable, the use of *renewable* resources must proceed at a rate that is less than or equal to the rate of natural replenishment. • To be sustainable, the rate of use of *non-renewable* resources must proceed at a rate that is declining, and the *rate of decline* must be greater than or equal to the *rate of depletion*.

Policies and Practices for Sustainable Cities

Sustainability, if rigorously defined, might appear to be an unachievable goal for a modern city. Growth in both population and consumption rates is almost everywhere taken for granted and encouraged, and the use of non-renewable resources, including fossil fuels, lies at the heart of most economic activities. Yet unless cities move in the direction of sustainability, they risk grave environmental, economic, and demographic problems.

Fortunately, public policy can help move cities in the direction of sustainability; indeed, there is a large and growing literature on ways to promote sustainability in ways that are both effective and politically acceptable.[14]

With regard to population growth and sprawl, it has been shown that costs to municipalities for new infrastructure requirements often outweigh the benefits of an enlarged tax base.[15] One useful tool in curbing sprawl is the creation of urban growth boundaries, as has been done in Portland, Oregon and several California cities.[16]

Consumption rates can be reined in with robust recycling and composting programs; with building standards that promote insulation and emphasize the use of environmentally friendly materials; and with heightened energy efficiency standards.[17]

Clearly, a central issue in achieving sustainability is reducing fossil fuel dependency. Cities can begin to kick the liquid hydrocarbon habit by investing in more efficient transport and transit modes (rail, light rail, streetcars, subways, and trolley bus systems), and in promoting bicycling and walking. Urban planning for density and mixed use gets people out of cars, so they can spend less time commuting and more time walking, shopping, and talking with friends.[18]

In cold climates like Edmonton's, reducing fossil fuel reliance requires addressing the requirement for space heating. The use of natural gas for heating can be greatly minimized with insulation and passive solar design, and with alternative heat sources such as geothermal heat pumps. In Germany, the *passivhaus* movement has resulted in the construction of over 20,000 buildings that require little or no energy for heating.[19]

Sourcing electrical power from renewable sources is also a major issue in reducing fossil fuel consumption. Often, decisions that determine the mix of energy sources used to provide electricity are made at the provincial or national level, or by private utilities. However, where cities have formed municipally owned power companies, they are better able to put these decisions in the hands of their citizens. Wind, geothermal, hydro, solar concentrating thermal, and photovoltaic power plants can all substitute for coal or gas power plants (nuclear power relies on another non-renewable resource—i.e., uranium ore). Some of these alternative energy sources are already economically competitive with fossil fuels. Choices regarding energy alternatives must be made on the basis of local potential renewable energy resources. It is noteworthy that Germany has become a world leader in installed solar photovoltaic generation capacity, even though it is situated at a latitude similar to that of Edmonton and enjoys relatively few sunny days.[20]

If a city is to be sustainable, its economic base must comply with the five axioms of sustainability. All communities rely on resource extraction indirectly, but some cities' economies are more directly tied to logging, mining, or fishing. Edmonton, with its considerable economic dependence on the extraction of a low-grade fossil fuel (oil sands), is vulnerable to boom-or-bust cycles caused by swings in oil prices. The best way to reduce that vulnerability would be to promote a more resilient, mixed economy based on the sustainable harvesting of renewable resources for energy, food, construction, and manufacturing.

Agriculture must be regarded as a central component of the economic base of any resilient, sustainable community. Local producers of food can be supported by regulations that facilitate development of community gardens, farmers markets, and school gardens; by encouraging school lunch programs to source ingredients from regional producers; and by establishing municipal food policy councils that operate less in the interest of global agribusiness and more in the interests of consumers and local producers.[21]

In northern climes, winter food production often depends on indoor horticulture—and cities, with millions of square meters of enclosed, heated space, offer abundant opportunities for small-scale growing. Recent innovations, such as indoor vertical farming, can be encouraged with tax incentives.[22]

"Go Local" and "Buy Local" campaigns and organizations are appearing in cities across North America, and many of these are associated with the Business Alliance for Local Living Economies (BALLE).[23] An example is the Sonoma County GoLocal Co-op, which is a network of locally-owned businesses, non-profit organizations, government agencies, and residents working together to build a resilient local economy by supporting local, independently owned businesses and promoting sustainable practices.[24]

Citizen-led movements for sustainability can be at least as effective as efforts by government officials. One that deserves mention is the Transition Initiatives, which began over four years ago in England and has since taken root throughout the U.K. and more recently in the U.S., Canada, and elsewhere.[25] Transition initiatives start with a small group concerned about dealing locally with issues of resource depletion and climate change, and with this question: "For all those aspects of life that this community needs in order to sustain itself and thrive, how do we significantly increase resilience and drastically reduce carbon emissions?" Initiatives strive to maintain a positive, hopeful, and collaborative stance, based on the belief that life can be better without fossil fuels. A Canadian Transition hub is now emerging to facilitate the emergence of local initiatives, and a Transition Edmonton initiative is already in its formative stages.[26]

Economic indices and targets give our society direction and tell us how we're doing at achieving our goals. The most common economic index, Gross Domestic Production or GDP (the monetary, market value of all final goods and services produced in a country over a period of a year), has been criticized as being inconsistent with three principles of good bookkeeping: it does not distinguish clearly between costs and benefits; it does not correct for changes in stocks and supplies; and it does not use accurate measures for all costs.[27] Many economists have advocated the development of more robust indicators, such as the Genuine Progress Indicator.[28] Implicit in alternative indices is the requirement to shift from measuring economic well-being in terms of increased consumption to counting factors of human welfare

(such as education), while subtracting costs of crime, pollution, and resource depletion.

A further examination of social sustainability—which focuses on matters such as public health, crime, and conflict resolution—is largely beyond the scope of this Discussion Paper. Nevertheless, it is worth noting that social sustainability seems to depend to a large extent on economic equity because, as has often been noted, extreme inequality seems to make societies vulnerable to internal social and political upheaval. According to the *British Medical Journal*, ". . . what matters in determining mortality and health in a society is less the overall wealth of that society and more how evenly wealth is distributed. The more equally wealth is distributed the better the health of that society."[29] Studies in the U.S. and elsewhere have reached the same conclusion.[30] Promotion of equity generally hinges on the use of taxes to create a basic safety net of public benefits and services.

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In summary: Sustainability is a challenging but essential goal for any city. Many societies in the past have failed to achieve it and suffered decline or collapse as a consequence. Fortunately, there are many things that Edmonton can do to move in the direction of long-term sustainability while also improving citizens' lives in the short term.

Notes

1. Eric Freyfogle, *Why Conservation Is Failing and How It Can Regain Ground* (Yale University Press, 2006)
2. See, for example, Joseph Tainter, *The Collapse of Complex Societies* (Cambridge University Press, 1988).
3. World Commission of Environment and Development, "Our Common Future" (1987), www.are.admin.ch/are/en/nachhaltig/international_uno/unterseite02330/
4. www.naturalstep.org
5. William E. Rees and Mathis Wackernagel, *Our Ecological Footprint* (New Society, 1995). www.footprintnetwork.org
6. Richard Heinberg, *Peak Everything: Waking Up to the Century of Declines* (New Society, 2007).

7. Jared Diamond, *Collapse: How Societies Choose to Fail or Succeed* (Viking, 2005).

8. Julian Simon, "The State of Humanity: Steadily Improving." *Cato Policy Report,* Vol. 17, No. 5, 131.

9. This is Albert A. Bartlett's First Law of Sustainability, reproduced verbatim—I found it impossible to improve upon. Albert A. Bartlett, "Reflections on Sustainability, Population Growth, and the Environment—Revisted." *Renewable Resources Journal*, Vol. 15, No. 4, Winter 1997-1998, 6-23. www.hubbertpeak.com/bartlett/reflections.htm

10. Efforts to refine this essential principle of sustainability are ongoing.

11. This principle was first stated, in a more generalized and more mathematically rigorous form, by Albert A. Bartlett in his 1986 paper, "Sustained Availability: A Management Program for Non-Renewable Resources" (*American Journal of Physics,* Vol. 54, May 1986, 398-402). The article's abstract notes: "If the rate of extraction declines at a fixed fraction per unit time, the rate of extraction will approach zero, but the integrated total of the extracted resource between t=0 and t=infinity will remain finite. If we choose a rate of decline of the rate of extraction of the resource such that the integrated total of all future extraction equals the present size of the remaining resource then we have a program that will allow the resource to be available in declining amounts for use forever." Annually reducing the rate of extraction of a given non-renewable resource by its yearly rate of depletion effectively accomplishes the same thing, but requires only simple arithmetic and layperson's terms for its explanation.)

12. Axiom 4 encapsulates Bartlett's 7th and 8th Laws of Sustainability. It is also the basis for the Oil Depletion Protocol, first suggested by petroleum geologist Colin J. Campbell in 1996 and the subject of a recent book by the present author (Richard Heinberg, *The Oil Depletion Protocol: A Plan to Avert Oil Wars, Terrorism and Economic Collapse,* New Society, 2006). The aim of the Oil Depletion Protocol is to reduce global consumption of petroleum in order to avert the crises likely to ensue as a result of declining supply—including economic collapse and resource wars. Under the terms of the Oil Depletion Protocol, oil-importing countries would reduce their imports by the world oil depletion rate (calculated by Campbell at 2.5 percent per year); producers would reduce their domestic production by their national depletion rates.)

13. This list of basic human needs was created by the Chilean economist, Manfred Max-Neef, and is used to define human needs for the fourth system condition of The Natural Step.

14. Two general resources along these lines are Daniel Lerch, *Post Carbon Cities* (Post Carbon Press, 2008); and Warren Karlenzig, *How Green Is Your City?* (New Society, 2007).

15. See: http://www.optimumpopulation.org/opt.optimum.html, http://www.planninginstitute.org/index.php?option=content&task=view&id=269&Itemid=; http://www.npg.org/forum_series/optimal_city_size.htm

16. See http://en.wikipedia.org/wiki/Urban_growth_boundary

17. See, for example, the Toronto Environmental Portal http://www.toronto.ca/environment/.

18. Urban planning, New Urbanism, Ecocities

19. See http://www.passiv.de/English/PassiveH.HTM, http://www.passivehouse.us/passiveHouse/PHIUSHome.html, http://en.wikipedia.org/wiki/Passive_house

20. Richard Heinberg, *Searching for a Miracle: Net Energy Limits and the Fate of Industrial Societies* (Post Carbon Institute and International Forum on Globalization, 2009), http://www.postcarbon.org/report/44377-searching-for-a-miracle

21. See, for example, the Oakland Food Policy Council http://www.oaklandfood.org/home.

22. See http://www.verticalfarm.com/; http://www.urbanfarmhub.org/2010/03/aerofarms-seeding-the-cities-of-the-future-with-indoor-farms/; http://manhattanfarming.com/; http://videosift.com/video/Vertical-Farms-Indoor-Hydroponic-Agriculture

23. http://www.livingeconomies.org/

24. http://sonomacounty.golocal.coop/

25. http://www.transitionnetwork.org/

26. http://transitioned.org/

27. For one example, see Dasgupta, P., and K.-G. Mäler (2000), "Net national product, wealth, and social well-being." *Environment and Development Economics* 5(1-2): 69-93.

28. The GPI was developed by the non-profit organization Reinventing Progress.

    http://www.rprogress.org/sustainability_indicators/genuine_progress_indicator.htm

29. Editorial, "The Big Idea," *British Medical Journal* Vol. 312 (April 20, 1996), pg. 985.

30. George A. Kaplan and others, "Inequality in income and mortality in the United States: analysis of mortality and potential pathways," *British Medical Journal*. 312 (April 20, 1996), pgs. 999-1003; Bruce P. Kennedy and others, "Income distribution and mortality: cross sectional ecological study of the Robin Hood index in the United States," *British Medical Journal* Vol. 312 (April 20, 1996), pgs. 1004-1007; Richard G. Wilkinson, "Income distribution and life expectancy," *British Medical Journal* Vol. 304 (January 18, 1992), pgs. 165-168. See also http://www.huppi.com/kangaroo/Inequality&Health.htm