Sustainability

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In ecology, **sustainability** (from *sustain* and *ability*) is the property of biological systems to remain diverse and productive indefinitely. Long-lived and healthy wetlands and forests are examples of sustainable biological systems. In more general terms, sustainability is the endurance of systems and processes. The organizing principle for sustainability is sustainable development, which includes the four interconnected domains: ecology, economics, politics and culture.[1] Sustainability science is the study of sustainable development and environmental science.[2]

Achieving sustainability will enable the Earth to continue supporting human life.

Sustainability can also be defined as a socio-ecological process characterized by the pursuit of a common ideal.[3] An ideal is by definition unattainable in a given time/space but endlessly approachable and it is this endless pursuit that forms a sustainable system in the process (ibid). Healthy ecosystems and environments are necessary to the survival of humans and other organisms. Ways of reducing negative human impact are environmentally-friendly chemical engineering, environmental resources management and environmental protection. Information is gained from green chemistry, earth science, environmental science and conservation biology. Ecological economics studies the fields of academic research that aim to address human economies and natural ecosystems.

Moving towards sustainability is also a social challenge that entails international and national law, urban planning and transport, local and individual lifestyles and ethical consumerism. Ways of living more sustainably can take many forms from reorganizing living conditions (e.g., ecovillages, eco-municipalities and sustainable cities), reappraising economic sectors (permaculture, green building, sustainable agriculture), or work practices (sustainable architecture), using science to develop new technologies (green technologies, renewable energy and sustainable fission and fusion power), or designing systems in a flexible and reversible manner,[4][5] and adjusting individual lifestyles that conserve natural resources.[6]

Batad rice terraces, The Philippines —UNESCO World Heritage site

"The term 'sustainability' should be viewed as humanity's target goal of human-ecosystem equilibrium (homeostasis), while 'sustainable development' refers to the holistic approach and temporal processes that lead us to the end point of sustainability." (305)[7] Despite the increased popularity of the use of the term "sustainability", the possibility that human societies will achieve environmental sustainability has been, and continues to be, questioned—in light of environmental degradation, climate change, overconsumption, population growth and societies' pursuit of unlimited economic growth in a closed system.[8][9]

Contents

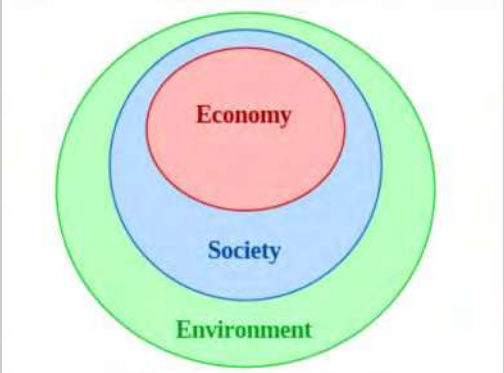
Etymology

The name sustainability is derived from the Latin *sustinere* (*tenere*, to hold; *sub*, up). *Sustain* can mean “maintain", "support", or "endure”.[10][11] Since the 1980s *sustainability* has been used more in the sense of human sustainability on planet Earth and this has resulted in the most widely quoted definition of sustainability as a part of the concept *sustainable development*, that of the Brundtland Commission of the United Nations on March 20, 1987: “sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs.”[12][13]

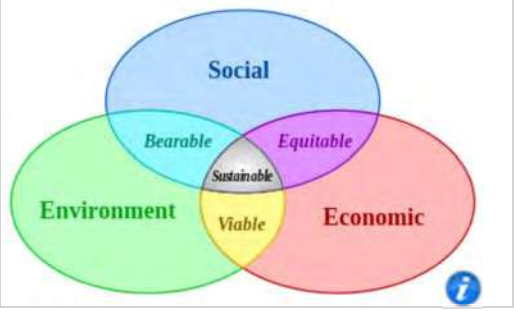
Components

Three pillars of sustainability

The 2005 World Summit on Social Development identified sustainable development goals, such as economic development, social development and environmental protection.[16] This view has been expressed as an illustration using three overlapping ellipses indicating that the three pillars of sustainability are not mutually exclusive and can be mutually reinforcing.[17] In fact, the three pillars are interdependent, and in the long run none can exist without the others.[18] The three pillars have served as a common ground for numerous sustainability standards and certification systems in recent years, in particular in the food industry.[19][20] Standards which today explicitly refer to the triple bottom line include Rainforest Alliance, Fairtrade and UTZ Certified.[21][22] Some sustainability experts and practitioners have illustrated four pillars of sustainability, or a quadruple bottom line. One such pillar is future generations, which emphasizes the long-term thinking associated with sustainability.[23] There is also an opinion that considers resource use and financial sustainability as two additional pillars of sustainability.[24]



A diagram indicating the relationship between the "three pillars of sustainability", in which both economy and society are constrained by environmental limits[14]



Venn diagram of sustainable development: at the confluence of three constituent parts[15]

Sustainable development consists of balancing local and global efforts to meet basic human needs without destroying or degrading the natural environment.[25][26][27] The question then becomes how to represent the relationship between those needs and the environment.

A study from 2005 pointed out that environmental justice is as important as sustainable development.[28] Ecological economist Herman Daly asked, "what use is a sawmill without a forest?"[29] From this perspective, the economy is a subsystem of human society, which is itself a subsystem of the biosphere, and a gain in one sector is a loss from another.[30] This perspective led to the nested circles figure of 'economics' inside 'society' inside the 'environment'.

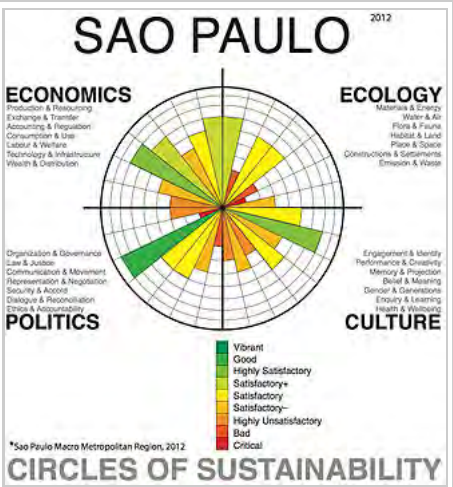
The simple definition that sustainability is something that improves "the quality of human life while living within the carrying capacity of supporting eco-systems",[31] though vague, conveys the idea of sustainability having quantifiable limits. But sustainability is also a call to action, a task in progress or “journey” and therefore a political process, so some definitions set out common goals and values.[32] The Earth Charter[33] speaks of “a sustainable global society founded on respect for nature, universal human rights, economic justice, and a culture of peace.” This suggested a more complex figure of sustainability, which included the importance of the domain of 'politics'.

More than that, sustainability implies responsible and proactive decision-making and innovation that minimizes negative impact and maintains balance between ecological resilience, economic prosperity, political justice and cultural vibrancy to ensure a desirable planet for all species now and in the future.[34] Specific types

of sustainability include, sustainable agriculture, sustainable architecture or ecological economics.[35] Understanding sustainable development is important but without clear targets an unfocused term like "liberty" or "justice".[36] It has also been described as a "dialogue of values that challenge the sociology of development".[37]

Circles of sustainability

While the United Nations Millennium Declaration identified principles and treaties on sustainable development, including economic development, social development and environmental protection it continued using three domains: economics, environment and social sustainability. More recently, using a systematic domain model that responds to the debates over the last decade, the Circles of Sustainability approach distinguished four domains of economic, ecological, political and cultural sustainability. This in accord with the United Nations Agenda 21, which specifies **culture** as the fourth domain of sustainable development.[39] The model is now being used by organizations such as the United Nations Cities Programme.[40] and Metropolis[41]



Urban sustainability analysis of the greater urban area of the city of São Paulo using the 'Circles of Sustainability' method of the UN and Metropolis Association.[38]

Seven modalities

Another model suggests humans attempt to achieve all of their needs and aspirations via seven modalities: economy, community, occupational groups, government, environment, culture, and physiology.[42] From the global to the individual human scale, each of the seven modalities can be viewed across seven hierarchical levels. Human sustainability can be achieved by attaining sustainability in all levels of the seven modalities.

Shaping the future

Integral elements of sustainability are research and innovation activities. A telling example is the European environmental research and innovation policy. It aims at defining and implementing a transformative agenda to greening the economy and the society as a whole so to make them sustainable. Research and innovation in Europe are financially supported by the programme Horizon 2020, which is also open to participation worldwide.[43] Encouraging good farming practices ensures farmers fully benefit from the environment and at the same time conserving it for future generations.

Resiliency

Resiliency in ecology is the capacity of an ecosystem to absorb disturbance and still retain its basic structure and viability. Resilience-thinking evolved from the need to manage interactions between human-constructed systems and natural ecosystems in a sustainable way despite the fact that to policymakers a definition remains elusive. Resilience-thinking addresses how much planetary ecological systems can withstand assault from human disturbances and still deliver the services current and future generations need from them. It is also concerned with commitment from geopolitical policymakers to promote and manage essential planetary ecological resources in order to promote resilience and achieve sustainability of these essential resources for

benefit of future generations of life?[44] The resiliency of an ecosystem, and thereby, its sustainability, can be reasonably measured at junctures or events where the combination of naturally occurring regenerative forces (solar energy, water, soil, atmosphere, vegetation, and biomass) interact with the energy released into the ecosystem from disturbances.[45]

A practical view of sustainability is closed systems that maintain processes of productivity indefinitely by replacing resources used by actions of people with resources of equal or greater value by those same people without degrading or endangering natural biotic systems.[46] In this way, sustainability can be concretely measured in human projects if there is a transparent accounting of the resources put back into the ecosystem to replace those displaced. In nature, the accounting occurs naturally through a process of adaptation as an ecosystem returns to viability from an external disturbance. The adaptation is a multi-stage process that begins with the disturbance event (earthquake, volcanic eruption, hurricane, tornado, flood, or thunderstorm), followed by absorption, utilization, or deflection of the energy or energies that the external forces created.[47]

In analysing systems such as urban and national parks, dams, farms and gardens, theme parks, open-pit mines, water catchments, one way to look at the relationship between sustainability and resiliency is to view the former with a long-term vision and resiliency as the capacity of human engineers to respond to immediate environmental events.[48]

History

The history of sustainability traces human-dominated ecological systems from the earliest civilizations to the present time.[49] This history is characterized by the increased regional success of a particular society, followed by crises that were either resolved, producing sustainability, or not, leading to decline.[50][51]

In early human history, the use of fire and desire for specific foods may have altered the natural composition of plant and animal communities.[52] Between 8,000 and 10,000 years ago, agrarian communities emerged which depended largely on their environment and the creation of a "structure of permanence."[53]

The Western industrial revolution of the 18th to 19th centuries tapped into the vast growth potential of the energy in fossil fuels. Coal was used to power ever more efficient engines and later to generate electricity. Modern sanitation systems and advances in medicine protected large populations from disease.[54] In the mid-20th century, a gathering environmental movement pointed out that there were environmental costs associated with the many material benefits that were now being enjoyed. In the late 20th century, environmental problems became global in scale.[55][56][57][58] The 1973 and 1979 energy crises demonstrated the extent to which the global community had become dependent on non-renewable energy resources.

In the 21st century, there is increasing global awareness of the threat posed by the human greenhouse effect, produced largely by forest clearing and the burning of fossil fuels.[59][60]

Principles and concepts

The philosophical and analytic framework of sustainability draws on and connects with many different disciplines and fields; in recent years an area that has come to be called sustainability science has emerged.[61]

Scale and context

Sustainability is studied and managed over many scales (levels or frames of reference) of time and space and in many contexts of environmental, social and economic organization. The focus ranges from the total carrying capacity (sustainability) of planet Earth to the sustainability of economic sectors, ecosystems, countries, municipalities, neighbourhoods, home gardens, individual lives, individual goods and services, occupations, lifestyles, behaviour patterns and so on. In short, it can entail the full compass of biological and human activity or any part of it.[62] As Daniel Botkin, author and environmentalist, has stated: "We see a landscape that is always in flux, changing over many scales of time and space."[63]

The sheer size and complexity of the planetary ecosystem has proved problematic for the design of practical measures to reach global sustainability. To shed light on the big picture, explorer and sustainability campaigner Jason Lewis has drawn parallels to other, more tangible closed systems. For example, he likens human existence on Earth — isolated as the planet is in space, whereby people cannot be evacuated to relieve population pressure and resources cannot be imported to prevent accelerated depletion of resources — to life at sea on a small boat isolated by water.[64] In both cases, he argues, exercising the precautionary principle is a key factor in survival.[65]

Consumption

A major driver of human impact on Earth systems is the destruction of biophysical resources, and especially, the Earth's ecosystems. The environmental impact of a community or of humankind as a whole depends both on population and impact per person, which in turn depends in complex ways on what resources are being used, whether or not those resources are renewable, and the scale of the human activity relative to the carrying capacity of the ecosystems involved. Careful resource management can be applied at many scales, from economic sectors like agriculture, manufacturing and industry, to work organizations, the consumption patterns of households and individuals and to the resource demands of individual goods and services.[66][67]

One of the initial attempts to express human impact mathematically was developed in the 1970s and is called the I PAT formula. This formulation attempts to explain human consumption in terms of three components: population numbers, levels of consumption (which it terms "affluence", although the usage is different), and impact per unit of resource use (which is termed "technology", because this impact depends on the technology used). The equation is expressed:

$$I = P \times A \times T$$

Where: I = Environmental impact, P = Population, A = Affluence, T = Technology[68]

Measurement

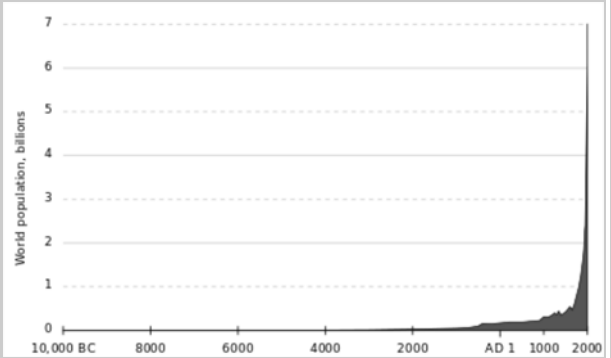
Sustainability measurement is a term that denotes the measurements used as the quantitative basis for the informed management of sustainability.[69] The metrics used for the measurement of sustainability (involving the sustainability of environmental, social and economic domains, both individually and in various combinations) are evolving: they include indicators, benchmarks, audits, sustainability standards and certification systems like Fairtrade and Organic, indexes and accounting, as well as assessment, appraisal[70] and other reporting systems. They are applied over a wide range of spatial and temporal scales.[71][72]

Some of the best known and most widely used sustainability measures include corporate sustainability reporting, Triple Bottom Line accounting, World Sustainability Society, Circles of Sustainability, and estimates of the quality of sustainability governance for individual countries using the Environmental Sustainability

Index and Environmental Performance Index.

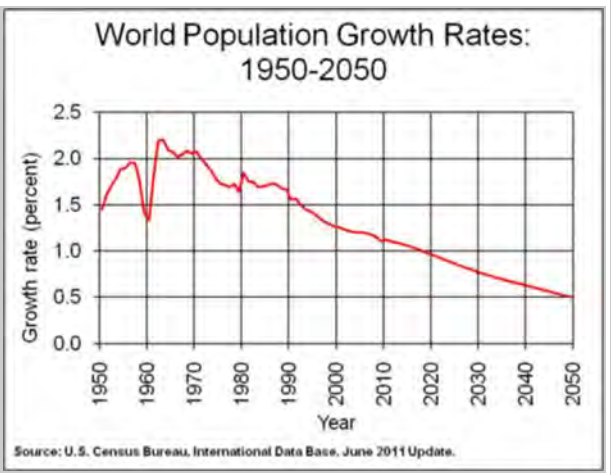
Population

According to the 2008 Revision of the official United Nations population estimates and projections, the world population is projected to reach 7 billion early in 2012, up from the current 6.9 billion (May 2009), to exceed 9 billion people by 2050. Most of the increase will be in developing countries whose population is projected to rise from 5.6 billion in 2009 to 7.9 billion in 2050. This increase will be distributed among the population aged 15–59 (1.2 billion) and 60 or over (1.1 billion) because the number of children under age 15 in developing countries is predicted to decrease. In contrast, the population of the more developed regions is expected to undergo only slight increase from 1.23 billion to 1.28 billion, and this would have declined to 1.15 billion but for a projected net migration from developing to developed countries, which is expected to average 2.4 million persons annually from 2009 to 2050.[73] Long-term estimates in 2004 of global population suggest a peak at around 2070 of nine to ten billion people, and then a slow decrease to 8.4 billion by 2100.[74]



Graph showing human population growth from 10,000 BC – 2000 AD, illustrating current exponential growth

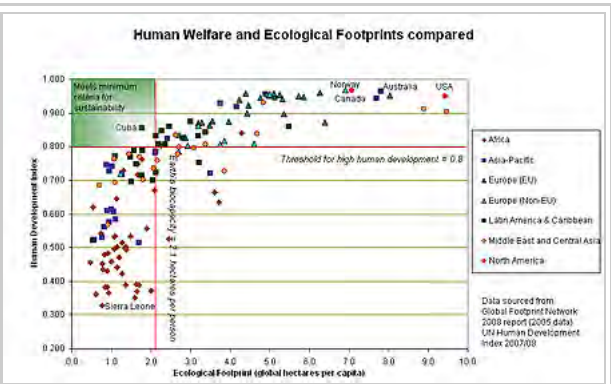
Emerging economies like those of China and India aspire to the living standards of the Western world as does the non-industrialized world in general.[75] It is the combination of population increase in the developing world and unsustainable consumption levels in the developed world that poses a stark challenge to sustainability.[76]



World population growth rate, 1950–2050, as estimated in 2011 by the U.S. Census Bureau, International Data Base

Carrying capacity

At the global scale, scientific data now indicates that humans are living beyond the carrying capacity of planet Earth and that this cannot continue indefinitely. This scientific evidence comes from many sources but is presented in detail in the Millennium Ecosystem Assessment and the planetary boundaries framework.[77] An early detailed examination of global limits was published in the 1972 book *Limits to Growth*, which has prompted follow-up commentary and analysis.[78] A 2012 review in *Nature* by 22 international researchers expressed concerns that the Earth may be "approaching a state shift" in its biosphere.[79]



Ecological footprint for different nations compared to their Human Development Index (HDI)

The Ecological footprint measures human consumption in

terms of the biologically productive land needed to provide the resources, and absorb the wastes of the average global citizen. In 2008 it required 2.7 global hectares per person, 30% more than the natural biological capacity of 2.1 global hectares (assuming no provision for other organisms).[56] The resulting ecological deficit must be met from unsustainable *extra* sources and these are obtained in three ways: embedded in the goods and services of world trade; taken from the past (e.g. fossil fuels); or borrowed from the future as unsustainable resource usage (e.g. by over exploiting forests and fisheries).

The figure (right) examines sustainability at the scale of individual countries by contrasting their Ecological Footprint with their UN Human Development Index (a measure of standard of living). The graph shows what is necessary for countries to maintain an acceptable standard of living for their citizens while, at the same time, maintaining sustainable resource use. The general trend is for higher standards of living to become less sustainable. As always, population growth has a marked influence on levels of consumption and the efficiency of resource use.[68][80] The sustainability goal is to raise the global standard of living without increasing the use of resources beyond globally sustainable levels; that is, to not exceed "one planet" consumption. Information generated by reports at the national, regional and city scales confirm the global trend towards societies that are becoming less sustainable over time.[81][82]

Romanian American economist Nicholas Georgescu-Roegen, a progenitor in economics and a paradigm founder of ecological economics, has argued that the carrying capacity of Earth — that is, Earth's capacity to sustain human populations and consumption levels — is bound to decrease sometime in the future as Earth's finite stock of mineral resources is presently being extracted and put to use.[83]:303 Leading ecological economist and steady-state theorist Herman Daly, a student of Georgescu-Roegen, has propounded the same argument.[84]:369–371

Global human impact on biodiversity

At a fundamental level energy flow and biogeochemical cycling set an upper limit on the number and mass of organisms in any ecosystem.[85] Human impacts on the Earth are demonstrated in a general way through detrimental changes in the global biogeochemical cycles of chemicals that are critical to life, most notably those of water, oxygen, carbon, nitrogen and phosphorus.[86]

The *Millennium Ecosystem Assessment* is an international synthesis by over 1000 of the world's leading biological scientists that analyzes the state of the Earth’s ecosystems and provides summaries and guidelines for decision-makers. It concludes that human activity is having a significant and escalating impact on the biodiversity of world ecosystems, reducing both their resilience and biocapacity. The report refers to natural systems as humanity's "life-support system", providing essential "ecosystem services". The assessment measures 24 ecosystem services concluding that only four have shown improvement over the last 50 years, 15 are in serious decline, and five are in a precarious condition.[87]

Sustainable development goals

The Sustainable Development Goals (SDGs) are the current harmonized set of seventeen future international development targets.

The Official Agenda for Sustainable Development adopted on 25 September 2015 has 92 paragraphs, with the main paragraph (51) outlining the 17 Sustainable Development Goals and its associated 169 targets. This included the following seventeen goals:[88]

1. **Poverty** – End poverty in all its forms everywhere[89]
2. **Food** – End hunger, achieve food security and improved nutrition and promote sustainable agriculture[90]
3. **Health** – Ensure healthy lives and promote well-being for all at all ages[91]
4. **Education** – Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all[92]
5. **Women** – Achieve gender equality and empower all women and girls[93]
6. **Water** – Ensure availability and sustainable management of water and sanitation for all[94]
7. **Energy** – Ensure access to affordable, reliable, sustainable and modern energy for all[95]
8. **Economy** – Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all[96]
9. **Infrastructure** – Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation[97]
10. **Inequality** – Reduce inequality within and among countries[98]
11. **Habitation** – Make cities and human settlements inclusive, safe, resilient and sustainable[99]
12. **Consumption** – Ensure sustainable consumption and production patterns[100]
13. **Climate** – Take urgent action to combat climate change and its impacts[101]
14. **Marine-ecosystems** – Conserve and sustainably use the oceans, seas and marine resources for sustainable development[102]
15. **Ecosystems** – Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss[103]
16. **Institutions** – Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels[104]
17. **Sustainability** – Strengthen the means of implementation and revitalize the global partnership for sustainable development[105]

As of August 2015, there were 169 proposed targets for these goals and 304 proposed indicators to show compliance.[106]

The Sustainable Development Goals (SDGs) replace the eight Millennium Development Goals (MDGs), which expired at the end of 2015. The MDGs were established in 2000 following the Millennium Summit of the United Nations. Adopted by the 189 United Nations member states at the time and more than twenty international organizations, these goals were advanced to help achieve the following sustainable development standards by 2015.

1. To eradicate extreme poverty and hunger
2. To achieve universal primary education
3. To promote gender equality and empower women
4. To reduce child mortality
5. To improve maternal health
6. To combat HIV/AIDS, malaria, and other diseases
7. To ensure environmental sustainability (one of the targets in this goal focuses on increasing sustainable access to safe drinking water and basic sanitation)
8. To develop a global partnership for development

Sustainable development

According to the data that member countries represented to the United Nations, Cuba was the only nation in the world in 2006 that met the World Wide Fund for Nature's definition of sustainable development, with an ecological footprint of less than 1.8 hectares per capita, 1.5, and a Human Development Index of over 0.8, 0.855.[107][108]

Environmental dimension

Healthy ecosystems provide vital goods and services to humans and other organisms. There are two major ways of reducing negative human impact and enhancing ecosystem services and the first of these is environmental management. This direct approach is based largely on information gained from earth science, environmental science and conservation biology. However, this is management at the end of a long series of indirect causal factors that are initiated by human consumption, so a second approach is through demand management of human resource use.

Management of human consumption of resources is an indirect approach based largely on information gained from economics. Herman Daly has suggested three broad criteria for ecological sustainability: renewable resources should provide a sustainable yield (the rate of harvest should not exceed the rate of regeneration); for non-renewable resources there should be equivalent development of renewable substitutes; waste generation should not exceed the assimilative capacity of the environment.[109]

Environmental management

At the global scale and in the broadest sense environmental management involves the oceans, freshwater systems, land and atmosphere, but following the sustainability principle of scale it can be equally applied to any ecosystem from a tropical rainforest to a home garden.[110][111]

Atmosphere

At a March 2009 meeting of the Copenhagen Climate Council, 2,500 climate experts from 80 countries issued a keynote statement that there is now "no excuse" for failing to act on global warming and that without strong carbon reduction "abrupt or irreversible" shifts in climate may occur that "will be very difficult for contemporary societies to cope with".[112][113] Management of the global atmosphere now involves assessment of all aspects of the carbon cycle to identify opportunities to address human-induced climate change and this has become a major focus of scientific research because of the potential catastrophic effects on biodiversity and human communities (see Energy below).

Other human impacts on the atmosphere include the air pollution in cities, the pollutants including toxic chemicals like nitrogen oxides, sulfur oxides, volatile organic compounds and airborne particulate matter that produce photochemical smog and acid rain, and the chlorofluorocarbons that degrade the ozone layer. Anthropogenic particulates such as sulfate aerosols in the atmosphere reduce the direct irradiance and reflectance (albedo) of the Earth's surface. Known as global dimming, the decrease is estimated to have been about 4% between 1960 and 1990 although the trend has subsequently reversed. Global dimming may have disturbed the global water cycle by reducing evaporation and rainfall in some areas. It also creates a cooling effect and this may have partially masked the effect of greenhouse gases on global warming.[114]

Freshwater and oceans

Water covers 71% of the Earth's surface. Of this, 97.5% is the salty water of the oceans and only 2.5%

freshwater, most of which is locked up in the Antarctic ice sheet. The remaining freshwater is found in glaciers, lakes, rivers, wetlands, the soil, aquifers and atmosphere. Due to the water cycle, fresh water supply is continually replenished by precipitation, however there is still a limited amount necessitating management of this resource. Awareness of the global importance of preserving water for ecosystem services has only recently emerged as, during the 20th century, more than half the world's wetlands have been lost along with their valuable environmental services. Increasing urbanization pollutes clean water supplies and much of the world still does not have access to clean, safe water.[115] Greater emphasis is now being placed on the improved management of blue (harvestable) and green (soil water available for plant use) water, and this applies at all scales of water management.[116]

Ocean circulation patterns have a strong influence on climate and weather and, in turn, the food supply of both humans and other organisms. Scientists have warned of the possibility, under the influence of climate change, of a sudden alteration in circulation patterns of ocean currents that could drastically alter the climate in some regions of the globe.[117] Ten per cent of the world's population – about 600 million people – live in low-lying areas vulnerable to sea level rise.

Land use

Loss of biodiversity stems largely from the habitat loss and fragmentation produced by the human appropriation of land for development, forestry and agriculture as natural capital is progressively converted to man-made capital. Land use change is fundamental to the operations of the biosphere because alterations in the relative proportions of land dedicated to urbanisation, agriculture, forest, woodland, grassland and pasture have a marked effect on the global water, carbon and nitrogen biogeochemical cycles and this can impact negatively on both natural and human systems.[118] At the local human scale, major sustainability benefits accrue from sustainable parks and gardens and green cities.[119][120]

A rice paddy in Bangladesh. Rice, wheat, corn and potatoes make up more than half the world's food supply.

Since the Neolithic Revolution about 47% of the world's forests have been lost to human use. Present-day forests occupy about a quarter of the world's ice-free land with about half of these occurring in the tropics.[121] In temperate and boreal regions forest area is gradually increasing (with the exception of Siberia), but deforestation in the tropics is of major concern.[122]

Food is essential to life. Feeding more than seven billion human bodies takes a heavy toll on the Earth's resources. This begins with the appropriation of about 38% of the Earth's land surface[123] and about 20% of its net primary productivity.[124] Added to this are the resource-hungry activities of industrial agribusiness – everything from the crop need for irrigation water, synthetic fertilizers and pesticides to the resource costs of food packaging, transport (now a major part of global trade) and retail. Environmental problems associated with industrial agriculture and agribusiness are now being addressed through such movements as sustainable agriculture, organic farming and more sustainable business practices.[125]

Management of human consumption

The underlying driver of direct human impacts on the environment is human consumption.[126] This impact is reduced by not only consuming less but by also making the full cycle of production, use and disposal more

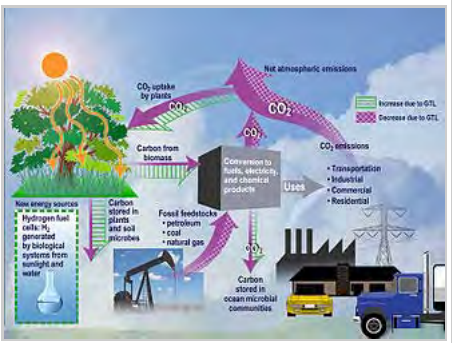
sustainable. Consumption of goods and services can be analysed and managed at all scales through the chain of consumption, starting with the effects of individual lifestyle choices and spending patterns, through to the resource demands of specific goods and services, the impacts of economic sectors, through national economies to the global economy.[127] Analysis of consumption patterns relates resource use to the environmental, social and economic impacts at the scale or context under investigation. The ideas of embodied resource use (the total resources needed to produce a product or service), resource intensity, and resource productivity are important tools for understanding the impacts of consumption. Key resource categories relating to human needs are food, energy, materials and water.

Helix of sustainability – the carbon cycle of manufacturing

In 2010, the International Resource Panel, hosted by the United Nations Environment Programme (UNEP), published the first global scientific assessment on the impacts of consumption and production[128] and identified priority actions for developed and developing countries. The study found that the most critical impacts are related to ecosystem health, human health and resource depletion. From a production perspective, it found that fossil-fuel combustion processes, agriculture and fisheries have the most important impacts. Meanwhile, from a final consumption perspective, it found that household consumption related to mobility, shelter, food and energy-using products cause the majority of life-cycle impacts of consumption.

Energy

The Sun's energy, stored by plants (primary producers) during photosynthesis, passes through the food chain to other organisms to ultimately power all living processes. Since the industrial revolution the concentrated energy of the Sun stored in fossilized plants as fossil fuels has been a major driver of technology which, in turn, has been the source of both economic and political power. In 2007 climate scientists of the IPCC concluded that there was at least a 90% probability that atmospheric increase in CO_2 was human-induced, mostly as a result of fossil fuel emissions but, to a lesser extent from changes in land use. Stabilizing the world's climate will require high-income countries to reduce their emissions by 60–90% over 2006 levels by 2050 which should hold CO_2 levels at 450–650 ppm from current levels of about 380 ppm. Above this level, temperatures could rise by more than 2 °C to produce "catastrophic" climate change.[129][130] Reduction of current CO_2 levels must be achieved against a background of global population increase and developing countries aspiring to energy-intensive high consumption Western lifestyles.[131]



Flow of CO_2 in an ecosystem

Reducing greenhouse emissions, is being tackled at all scales, ranging from tracking the passage of carbon through the carbon cycle[132] to the commercialization of renewable energy, developing less carbon-hungry technology and transport systems and attempts by individuals to lead carbon neutral lifestyles by monitoring the fossil fuel use embodied in all the goods and services they use.[133] Engineering of emerging technologies such as carbon-neutral fuel[134][135][136] and energy storage systems such as power to gas, compressed air energy storage,[137][138] and pumped-storage hydroelectricity[139][140][141] are necessary to store power from transient renewable energy sources including emerging renewables such as airborne wind turbines.[142]

Water

Water security and food security are inextricably linked. In the decade 1951–60 human water withdrawals were four times greater than the previous decade. This rapid increase resulted from scientific and technological developments impacting through the economy – especially the increase in irrigated land, growth in industrial and power sectors, and intensive dam construction on all continents. This altered the water cycle of rivers and lakes, affected their water quality and had a significant impact on the global water cycle.[143] Currently towards 35% of human water use is unsustainable, drawing on diminishing aquifers and reducing the flows of major rivers: this percentage is likely to increase if climate change impacts become more severe, populations increase, aquifers become progressively depleted and supplies become polluted and unsanitary.[144] From 1961 to 2001 water demand doubled — agricultural use increased by 75%, industrial use by more than 200%, and domestic use more than 400%.[145] In the 1990s it was estimated that humans were using 40–50% of the globally available freshwater in the approximate proportion of 70% for agriculture, 22% for industry, and 8% for domestic purposes with total use progressively increasing.[143]

Water efficiency is being improved on a global scale by increased demand management, improved infrastructure, improved water productivity of agriculture, minimising the water intensity (embodied water) of goods and services, addressing shortages in the non-industrialized world, concentrating food production in areas of high productivity, and planning for climate change, such as through flexible system design. A promising direction towards sustainable development is to design systems that are flexible and reversible.[4][5] At the local level, people are becoming more self-sufficient by harvesting rainwater and reducing use of mains water.[116][146]

Food

Feijoada — A typical black bean food dish from Brazil

The American Public Health Association (APHA) defines a "sustainable food system"[147][148] as "one that provides healthy food to meet current food needs while maintaining healthy ecosystems that can also provide food for generations to come with minimal negative impact to the environment. A sustainable food system also encourages local production and distribution infrastructures and makes nutritious food available, accessible, and affordable to all. Further, it is humane and just, protecting farmers and other workers, consumers, and communities."[149] Concerns about the environmental impacts of agribusiness and the stark contrast between the obesity problems of the Western world and the poverty and food insecurity of the developing world have generated a strong movement towards healthy, sustainable eating as a major component of overall ethical consumerism.[150] The environmental effects of different dietary patterns depend on many factors, including the proportion of animal and plant foods consumed and the method of food production.[151][152][153][154] The World Health Organization has published a *Global Strategy on Diet, Physical Activity and Health* report which was endorsed by the May 2004 World Health Assembly. It recommends the Mediterranean diet which is associated with health and longevity and is low in meat, rich in fruits and vegetables, low in added sugar and limited salt, and low in saturated fatty acids; the traditional source of fat in the Mediterranean is olive oil, rich in monounsaturated fat. The healthy rice-based Japanese diet is also high in carbohydrates and low in fat. Both diets are low in meat and saturated fats and high in legumes and other vegetables; they are associated with a low incidence of ailments and low environmental impact.[155]

At the global level the environmental impact of agribusiness is being addressed through sustainable agriculture and organic farming. At the local level there are various movements working towards local food production, more productive use of urban wastelands and domestic gardens including permaculture, urban horticulture, local food, slow food, sustainable gardening, and organic gardening.[156][157]

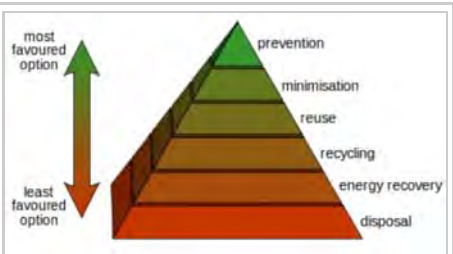
Sustainable seafood is seafood from either fished or farmed sources that can maintain or increase production in the future without jeopardizing the ecosystems from which it was acquired. The sustainable seafood movement has gained momentum as more people become aware about both overfishing and environmentally destructive fishing methods.

Materials, toxic substances, waste

An electric wire reel reused as a center table in a Rio de Janeiro decoration fair. The reuse of materials is a sustainable practice that is rapidly growing among designers in Brazil.

As global population and affluence has increased, so has the use of various materials increased in volume, diversity and distance transported. Included here are raw materials, minerals, synthetic chemicals (including hazardous substances), manufactured products, food, living organisms and waste.[158] By 2050, humanity could consume an estimated 140 billion tons of minerals, ores, fossil fuels and biomass per year (three times its current amount) unless the economic growth rate is decoupled from the rate of natural resource consumption. Developed countries' citizens consume an average of 16 tons of those four key resources per capita, ranging up to 40 or more tons per person in some developed countries with resource consumption levels far beyond what is likely sustainable.[159]

Sustainable use of materials has targeted the idea of dematerialization, converting the linear path of materials (extraction, use, disposal in landfill) to a circular material flow that reuses materials as much as possible, much like the cycling and reuse of waste in nature.[160] This approach is supported by product stewardship and the increasing use of material flow analysis at all levels, especially individual countries and the global economy.[161] The use of sustainable biomaterials that come from renewable sources and that can be recycled is preferred to the use on non-renewables from a life cycle standpoint.



The waste hierarchy

Synthetic chemical production has escalated following the stimulus it received during the second World War. Chemical production includes everything from herbicides, pesticides and fertilizers to domestic chemicals and hazardous substances.[162] Apart from the build-up of greenhouse gas emissions in the atmosphere, chemicals of particular concern include: heavy metals, nuclear waste, chlorofluorocarbons, persistent organic pollutants and all harmful chemicals capable of bioaccumulation. Although most synthetic chemicals are harmless there needs to be rigorous testing of new chemicals, in all countries, for adverse environmental and health effects. International legislation has been established to deal with the global distribution and management of dangerous goods.[163][164] The effects of some chemical agents needed long-term measurements and a lot of legal battles to realize their danger to human health. The classification of the toxic carcinogenic agents is handle by the International Agency for Research on Cancer.

Every economic activity produces material that can be classified as waste. To reduce waste, industry, business and government are now mimicking nature by turning the waste produced by industrial metabolism into resource. Dematerialization is being encouraged through the ideas of industrial ecology, ecodesign[165] and ecolabelling. In addition to the well-established “reduce, reuse and recycle,” shoppers are using their purchasing power for ethical consumerism.[67]

The European Union is expected to table by the end of 2015 an ambitious Circular Economy package which is expected to include concrete legislative proposals on waste management, ecodesign and limits on land fills.

Economic dimension

The *Great Fish Market*, painted by Jan Brueghel the Elder

On one account, sustainability "concerns the specification of a set of actions to be taken by present persons that will not diminish the prospects of future persons to enjoy levels of consumption, wealth, utility, or welfare comparable to those enjoyed by present persons."[166] Sustainability interfaces with economics through the social and ecological consequences of economic activity.[29] Sustainability economics represents: "... a broad interpretation of ecological economics where environmental and ecological variables and issues are basic but part of a multidimensional perspective. Social, cultural, health-related and monetary/financial aspects have to be integrated into the analysis."[167] However, the concept of sustainability is much broader than the concepts of sustained yield of welfare, resources, or profit margins.[168] At present, the average per capita consumption of people in the developing world is sustainable but population numbers are increasing and individuals are aspiring to high-consumption Western lifestyles. The developed world population is only increasing slightly but consumption levels are unsustainable. The challenge for sustainability is to curb and manage Western consumption while raising the standard of living of the developing world without increasing its resource use and environmental impact. This must be done by using strategies and technology that break the link between, on the one hand, economic growth and on the other, environmental damage and resource depletion.[169]

A recent UNEP report proposes a green economy defined as one that “improves human well-being and social equity, while significantly reducing environmental risks and ecological scarcities”: it "does not favor one political perspective over another but works to minimize excessive depletion of natural capital". The report makes three key findings: “that greening not only generates increases in wealth, in particular a gain in ecological commons or natural capital, but also (over a period of six years) produces a higher rate of GDP growth”; that there is “an inextricable link between poverty eradication and better maintenance and conservation of the ecological commons, arising from the benefit flows from natural capital that are received directly by the poor”; "in the transition to a green economy, new jobs are created, which in time exceed the losses in “brown economy” jobs. However, there is a period of job losses in transition, which requires investment in re-skilling and re-educating the workforce”.[170]

Several key areas have been targeted for economic analysis and reform: the environmental effects of unconstrained economic growth; the consequences of nature being treated as an economic externality; and the possibility of an economics that takes greater account of the social and environmental consequences of market behavior.[171]

Decoupling environmental degradation and economic growth

Historically there has been a close correlation between economic growth and environmental degradation: as communities grow, so the environment declines. This trend is clearly demonstrated on graphs of human population numbers, economic growth, and environmental indicators.[172] Unsustainable economic growth has been starkly compared to the malignant growth of a cancer[173] because it eats away at the Earth's ecosystem services which are its life-support system. There is concern that, unless resource use is checked, modern global civilization will follow the path of ancient civilizations that collapsed through overexploitation of their resource base.[174][175] While conventional economics is concerned largely with economic growth and the efficient allocation of resources, ecological economics has the explicit goal of sustainable scale (rather than continual growth), fair distribution and efficient allocation, in that order.[176][177] The World Business Council for Sustainable Development states that "business cannot succeed in societies that fail".[178]

In economic and environmental fields, the term decoupling is becoming increasingly used in the context of economic production and environmental quality. When used in this way, it refers to the ability of an economy to grow without incurring corresponding increases in environmental pressure. Ecological economics includes the study of societal metabolism, the throughput of resources that enter and exit the economic system in relation to environmental quality.[177][179] An economy that is able to sustain GDP growth without having a negative impact on the environment is said to be decoupled. Exactly how, if, or to what extent this can be achieved is a subject of much debate. In 2011 the International Resource Panel, hosted by the United Nations Environment Programme (UNEP), warned that by 2050 the human race could be devouring 140 billion tons of minerals, ores, fossil fuels and biomass per year – three times its current rate of consumption – unless nations can make serious attempts at decoupling.[180] The report noted that citizens of developed countries consume an average of 16 tons of those four key resources per capita per annum (ranging up to 40 or more tons per person in some developed countries). By comparison, the average person in India today consumes four tons per year. Sustainability studies analyse ways to reduce resource intensity (the amount of resource (e.g. water, energy, or materials) needed for the production, consumption and disposal of a unit of good or service) whether this be achieved from improved economic management, product design, or new technology.[181]

There are conflicting views whether improvements in technological efficiency and innovation will enable a complete decoupling of economic growth from environmental degradation. On the one hand, it has been claimed repeatedly by efficiency experts that resource use intensity (i.e., energy and materials use per unit GDP) could in principle be reduced by at least four or five-fold, thereby allowing for continued economic growth without increasing resource depletion and associated pollution.[182][183] On the other hand, an extensive historical analysis of technological efficiency improvements has conclusively shown that improvements in the efficiency of the use of energy and materials were almost always outpaced by economic growth, in large part because of the rebound effect (conservation) or Jevons Paradox resulting in a net increase in resource use and associated pollution.[184][185] Furthermore, there are inherent thermodynamic (i.e., second law of thermodynamics) and practical limits to all efficiency improvements. For example, there are certain minimum unavoidable material requirements for growing food, and there are limits to making automobiles, houses, furniture, and other products lighter and thinner without the risk of losing their necessary functions.[186] Since it is both theoretically and practically impossible to increase resource use efficiencies indefinitely, it is equally impossible to have continued and infinite economic growth without a concomitant increase in resource depletion and environmental pollution, i.e., economic growth and resource depletion can be decoupled to some degree over the short run but not the long run. Consequently, long-term sustainability requires the transition to a steady state economy in which total GDP remains more or less constant, as has been advocated for decades by Herman Daly and others in the ecological economics community.

A different proposed solution to partially decouple economic growth from environmental degradation is the *restore* approach.[187] This approach views "restore" as a fourth component to the common reduce, reuse,

recycle motto. Participants in such efforts are encouraged to voluntarily donate towards nature conservation a small fraction of the financial savings they experience through a more frugal use of resources. These financial savings would normally lead to rebound effects, but a theoretical analysis suggests that donating even a small fraction of the experienced savings can potentially more than eliminate rebound effects.[187]

Nature as an economic externality

The economic importance of nature is indicated by the use of the expression ecosystem services to highlight the market relevance of an increasingly scarce natural world that can no longer be regarded as both unlimited and free.[188] In general, as a commodity or service becomes more scarce the price increases and this acts as a restraint that encourages frugality, technical innovation and alternative products. However, this only applies when the product or service falls within the market system.[189] As ecosystem services are generally treated as economic externalities they are unpriced and therefore overused and degraded, a situation sometimes referred to as the Tragedy of the Commons.[188]

Deforestation of native rain forest in Rio de Janeiro City for extraction of clay for civil engineering (2009 picture)

One approach to this dilemma has been the attempt to "internalize" these "externalities" by using market strategies like ecotaxes and incentives, tradeable permits for carbon, and the encouragement of payment for ecosystem services. Community currencies associated with Local Exchange Trading Systems (LETS), a gift economy and Time Banking have also been promoted as a way of supporting local economies and the environment.[190][191] Green economics is another market-based attempt to address issues of equity and the environment.[192] The global recession and a range of associated government policies are likely to bring the biggest annual fall in the world's carbon dioxide emissions in 40 years.[193]

Economic opportunity

Treating the environment as an externality may generate short-term profit at the expense of sustainability.[194] Sustainable business practices, on the other hand, integrate ecological concerns with social and economic ones (i.e., the triple bottom line).[195][196] Growth that depletes ecosystem services is sometimes termed "uneconomic growth" as it leads to a decline in quality of life.[197][198] Minimizing such growth can provide opportunities for local businesses. For example, industrial waste can be treated as an "economic resource in the wrong place". The benefits of waste reduction include savings from disposal costs, fewer environmental penalties, and reduced liability insurance. This may lead to increased market share due to an improved public image.[199][200] Energy efficiency can also increase profits by reducing costs.

The idea of sustainability as a business opportunity has led to the formation of organizations such as the Sustainability Consortium of the Society for Organizational Learning, the Sustainable Business Institute, and the World Council for Sustainable Development.[201] The expansion of sustainable business opportunities can contribute to job creation through the introduction of green-collar workers.[202] Research focusing on progressive corporate leaders who have integrated sustainability into commercial strategy has yielded a leadership competency model for sustainability,[203][204] and led to emergence of the concept of "embedded

sustainability" – defined by its authors Chris Laszlo and Nadya Zhexembayeva as "incorporation of environmental, health, and social value into the core business with no trade-off in price or quality – in other words, with no social or green premium."[205] Laszlo and Zhexembayeva's research showed that embedded sustainability offers at least seven distinct opportunities for business value creation: a) better risk-management, b) increased efficiency through reduced waste and resource use, c) better product differentiation, d) new market entrances, e) enhanced brand and reputation, f) greater opportunity to influence industry standards, and g) greater opportunity for radical innovation.[206] Nadya Zhexembayeva's 2014 research further suggested that innovation driven by resource depletion can result in fundamental advantages for company products and services, as well as the company strategy as a whole, when right principles of innovation are applied.[207]

Ecosocialist approach

One school of thought, often labeled ecosocialism or ecological Marxism, asserts that the capitalist economic system is fundamentally incompatible with the ecological and social requirements of sustainability.[208] This theory rests on the premises that:

1. Capitalism's sole economic purpose is "unlimited capital accumulation" in the hands of the capitalist class[209]
2. The urge to accumulate (the profit motive) drives capitalists to continually reinvest and expand production, creating indefinite and unsustainable economic growth[210][211]
3. "Capital tends to degrade the conditions of its own production" (the ecosystems and resources on which any economy depends)[212]

Thus, according to this analysis:

1. Giving economic priority to the fulfillment of human needs while staying within ecological limits, as sustainable development demands, is in conflict with the structural workings of capitalism[213]
2. A steady-state capitalist economy is impossible;[214] further, a steady-state capitalist economy is socially undesirable due to the inevitable outcome of massive unemployment and underemployment[215]
3. Capitalism will, unless overcome by revolution, run up against the physical limits of the biosphere and self-destruct[216]

By this logic, market-based solutions to ecological crises (ecological economics, environmental economics, green economy) are rejected as technical tweaks that do not confront capitalism's structural failures.[217][218] "Low-risk" technology/science-based solutions such as solar power, sustainable agriculture, and increases in energy efficiency are seen as necessary but insufficient.[219] "High-risk" technological solutions such as nuclear power and climate engineering are entirely rejected.[220] Attempts made by businesses to "greenwash" their practices are regarded as false advertising, and it is pointed out that implementation of renewable technology (such as Walmart's proposition to supply their electricity with solar power) has the effect opposite of reductions in resource consumption, viz. further economic growth.[221] Sustainable business models and the triple bottom line are viewed as morally praiseworthy but ignorant to the tendency in capitalism for the distribution of wealth to become increasingly unequal and socially unstable/unsustainable.[212][222] Ecosocialists claim that the general unwillingness of capitalists to tolerate—and capitalist governments to implement—constraints on maximum profit (such as ecotaxes or preservation and conservation measures) renders environmental reforms incapable of facilitating large-scale change: "History teaches us that although capitalism has at times responded to environmental movements . . . at a certain point, at which the system's underlying accumulation drive is affected, its resistance to environmental demands stiffens."[223] They also

note that, up until the event of total ecological collapse, destruction caused by natural disasters generally causes an increase in economic growth and accumulation; thus, capitalists have no foreseeable motivation to reduce the probability of disasters (i.e. convert to sustainable/ecological production).[224]

Ecosocialists advocate for the revolutionary succession of capitalism by ecosocialism—an egalitarian economic/political/social structure designed to harmonize human society with non-human ecology and to fulfill human needs—as the only sufficient solution to the present-day ecological crisis, and hence the only path towards sustainability.[225] Sustainability is viewed not as a domain exclusive to scientists, environmental activists, and business leaders but as a holistic project that must involve the whole of humanity redefining its place in Nature: "What every environmentalist needs to know . . . is that capitalism is not the solution but the problem, and that if humanity is going to survive this crisis, it will do so because it has exercised its capacity for human freedom, through social struggle, in order to create a whole new world—in coevolution with the planet."[226]

Social dimension

Sustainability issues are generally expressed in scientific and environmental terms, as well as in ethical terms of stewardship, but implementing change is a social challenge that entails, among other things, international and national law, urban planning and transport, local and individual lifestyles and ethical consumerism.[227] "The relationship between human rights and human development, corporate power and environmental justice, global poverty and citizen action, suggest that responsible global citizenship is an inescapable element of what may at first glance seem to be simply matters of personal consumer and moral choice."[228]

Peace, security, social justice

Social disruptions like war, crime and corruption divert resources from areas of greatest human need, damage the capacity of societies to plan for the future, and generally threaten human well-being and the environment.[228] Broad-based strategies for more sustainable social systems include: improved education and the political empowerment of women, especially in developing countries; greater regard for social justice, notably equity between rich and poor both within and between countries; and intergenerational equity.[76] Depletion of natural resources including fresh water[229] increases the likelihood of "resource wars".[230] This aspect of sustainability has been referred to as environmental security and creates a clear need for global environmental agreements to manage resources such as aquifers and rivers which span political boundaries, and to protect shared global systems including oceans and the atmosphere.[231]

Poverty

A major hurdle to achieve sustainability is the alleviation of poverty. It has been widely acknowledged that poverty is one source of environmental degradation. Such acknowledgment has been made by the Brundtland Commission report Our Common Future[232] and the Millennium Development Goals.[233] There is a growing realization in national governments and multilateral institutions that it is impossible to separate economic development issues from environment issues: according to the Brundtland report, "poverty is a major cause and effect of global environmental problems. It is therefore futile to attempt to deal with environmental problems without a broader perspective that encompasses the factors underlying world poverty and international inequality."[234] Individuals living in poverty tend to rely heavily on their local ecosystem as a source for basic needs (such as nutrition and medicine) and general well-being.[235] As population growth continues to increase, increasing pressure is being placed on the local ecosystem to provide these basic essentials.

According to the UN Population Fund, high fertility and poverty have been strongly correlated, and the world's poorest countries also have the highest fertility and population growth rates.[236] The word sustainability is also used widely by western country development agencies and international charities to focus their poverty alleviation efforts in ways that can be sustained by the local populace and its environment. For example, teaching water treatment to the poor by boiling their water with charcoal, would not generally be considered a sustainable strategy, whereas using PET solar water disinfection would be. Also, sustainable best practices can involve the recycling of materials, such as the use of recycled plastics for lumber where deforestation has devastated a country's timber base. Another example of sustainable practices in poverty alleviation is the use of exported recycled materials from developed to developing countries, such as Bridges to Prosperity's use of wire rope from shipping container gantry cranes to act as the structural wire rope for footbridges that cross rivers in poor rural areas in Asia and Africa.

Human relationship to nature

According to Murray Bookchin, the idea that humans must dominate nature is common in hierarchical societies. Bookchin contends that capitalism and market relationships, if unchecked, have the capacity to reduce the planet to a mere resource to be exploited. Nature is thus treated as a commodity: "The plundering of the human spirit by the market place is paralleled by the plundering of the earth by capital."[237] Social ecology, founded by Bookchin, is based on the conviction that nearly all of humanity's present ecological problems originate in, indeed are mere symptoms of, dysfunctional social arrangements. Whereas most authors proceed as if our ecological problems can be fixed by implementing recommendations which stem from physical, biological, economic etc., studies, Bookchin's claim is that these problems can only be resolved by understanding the underlying social processes and intervening in those processes by applying the concepts and methods of the social sciences.[238]

A pure capitalist approach has also been criticized in Stern Review on the Economics of Climate Change to mitigation the effects of global warming in this excerpt ...

> "the greatest example of market failure we have ever seen."[239][240]

Deep ecology is a movement founded by Arne Naess that establishes principles for the well-being of all life on Earth and the richness and diversity of life forms. The movement advocates, among other things, a substantial decrease in human population and consumption along with the reduction of human interference with the nonhuman world. To achieve this, deep ecologists advocate policies for basic economic, technological, and ideological structures that will improve the *quality of life* rather than the *standard of living*. Those who subscribe to these principles are obliged to make the necessary change happen.[241] The concept of a billion-year Sustainocene has been developed to initiate policy consideration of an earth where human structures power and fuel the needs of that species (for example through artificial photosynthesis) allowing Rights of Nature.[242]

Human settlements

One approach to sustainable living, exemplified by small-scale urban transition towns and rural ecovillages, seeks to create self-reliant communities based on principles of simple living, which maximize self-sufficiency particularly in food production. These principles, on a broader scale, underpin the

Sustainability principles

1. Reduce dependence upon fossil fuels, underground metals, and minerals
2. Reduce dependence upon synthetic chemicals

concept of a bioregional economy.[244] These approaches often utilize commons based knowledge sharing of open source appropriate technology.[245]

and other unnatural substances
3. Reduce encroachment upon nature
4. Meet human needs fairly & efficiently[243]

Other approaches, loosely based around New Urbanism, are successfully reducing environmental impacts by altering the built environment to create and preserve sustainable cities which support sustainable transport. Residents in compact urban neighborhoods drive fewer miles, and have significantly lower environmental impacts across a range of measures, compared with those living in sprawling suburbs.[246] In sustainable architecture the recent movement of New Classical Architecture promotes a sustainable approach towards construction, that appreciates and develops smart growth, architectural tradition and classical design.[247][248] This in contrast to modernist and globally uniform architecture, as well as opposing solitary housing estates and suburban sprawl.[249] Both trends started in the 1980s. The concept of Circular flow land use management has also been introduced in Europe to promote sustainable land use patterns that strive for compact cities and a reduction of greenfield land take by urban sprawl.

Large scale social movements can influence both community choices and the built environment. Eco-municipalities may be one such movement.[250] Eco-municipalities take a systems approach, based on sustainability principles. The eco-municipality movement is participatory, involving community members in a bottom-up approach. In Sweden, more than 70 cities and towns—25 per cent of all municipalities in the country—have adopted a common set of "Sustainability Principles" and implemented these systematically throughout their municipal operations. There are now twelve eco-municipalities in the United States and the American Planning Association has adopted sustainability objectives based on the same principles.[243]

There is a wealth of advice available to individuals wishing to reduce their personal and social impact on the environment through small, inexpensive and easily achievable steps.[251][252] But the transition required to reduce global human consumption to within sustainable limits involves much larger changes, at all levels and contexts of society.[253] The United Nations has recognised the central role of education, and have declared a decade of education for sustainable development, 2005–2014, which aims to "challenge us all to adopt new behaviours and practices to secure our future".[254] The Worldwide Fund for Nature proposes a strategy for sustainability that goes beyond education to tackle underlying individualistic and materialistic societal values head-on and strengthen people's connections with the natural world.[255]

Human and labor rights

Application of social sustainability requires stakeholders to look at human and labor rights, prevention of human trafficking, and other human rights risks.[256] These issues should be considered in production and procurement of various worldwide commodities. The international community has identified many industries whose practices have been known to violate social sustainability, and many of these industries have organizations in place that aid in verifying the social sustainability of products and services.[257] The Equator Principles (financial industry), Fair Wear Foundation (garments), and Electronics Industry Citizenship Coalition are examples of such organizations and initiatives. Resources are also available for verifying the life-cycle of products and the producer or vendor level, such as Green Seal for cleaning products, NSF-140 for carpet production, and even labeling of Organic food in the United States.[258]

See also

- Bibliography of sustainability
- List of sustainability topics
- Outline of sustainability
- Computational sustainability

Topics

- Applied sustainability
- Appropriate technology
- Carfree city
- Circles of Sustainability
- Cradle-to-cradle design
- Ecopsychology
- Environmental issue
- Extinction
- Human overpopulation
- Introduced species
- Micro-sustainability
- Pledge two or fewer (campaign for smaller families)
- Resource efficiency
- Sociocultural evolution
- Sustainability and systemic change resistance
- Sustainable development
- Sustainable Development Goals
- Sustainable forest management
- Sustainable living
- Sustainable sanitation
- Sustainability science
- Sustainability standards and certification
- Sustainability studies
- United Nations Agenda 21
- World Cities Summit
- Sustainable design
- Sustainable city

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