CHE 5105- Environmental Economics

The course aims to provide students with skills in the field of economics to the real environmental world; theoretical/empirical studies of the economic effects of national or local environmental policies with emphasis on costs and benefits of alternative policies to deal with earth resources, markets, solid waste, global warming, toxic substances, water quality and air pollution.

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1. INTRODUCTION

Environmental economics is a relatively new field of economics that looks at environmental issues in relation to economic development and sustainability. It looks a lot at environmental policies in countries, and how they impact the local and global economies, either positively or negatively. It is generally viewed as a form of progressive economics, trying to account for various forms of market failures to better model markets in the future and lead to more widespread gains among people.

One of the cornerstones of environmental economics is examining various causes of market failure. A market failure is said to have occurred when resources are not distributed in the most efficient manner, usually because of imperfect knowledge among the members of the market. The problem, then, is said not to be with the free market concept itself, but with the limitations of human understanding of market forces. Ideally, environmental economics views a healthy market as functioning such that all resources are distributed in such a way that they provide the greatest benefit to society; when this does not occur, the market can be said to have failed.

One key cause of market failure as seen by environmental economics is a misuse of common property. This was best elaborated in 1968 by Garrett Hardin as the Tragedy of the Commons. Simply put, the tragedy is that even when it is in everyone's best interest to use a resource reasonably, ensuring it remains around to deliver yields to everyone; a small handful of individuals can destroy the resource by acting out of greed. As technological development has increased, a number of finite commons have become apparent that were once viewed as infinite, and environmental economics therefore looks at them as potential sources of tragedy. Air, for example, is a common property, shared by all people of all nations. One nation, however, can emit large amounts of pollution, thereby damaging the common property for all nations, even those that reaped no economic benefit from the destructive behaviour of the single nation.

Another cause of market failure from an environmental economics perspective is a failure for markets to take externalized costs into account when determining a market value. The air pollution discussed above, for example, may be emitted without adding any cost to the product it creates, thereby making the pollution functionally left out of the market's price determination of a product. Therefore, a product produced without pollution and a product produced with pollution may find the same market price. Although it may cost more internally, in the form of money, to produce the product without pollution, however, the actual costs may be much greater for the polluting product. The long-term costs in terms of health, clean-up, and environmental aesthetics from the pollution can make the real cost much, much greater, but currently the market has no way of expressing that larger price.

One of the big missions of environmental economics is to better internalize external costs so that the market can react appropriately. The theory is that a sane market, which internalizes all costs, will consistently act in accordance with the greater good of society. A failed market, however, will often act directly against the needs of society, and environmental economics tries to highlight these failures so that nations can implement regulation to better steer the market. Things such as carbon capping and trading carbon credits are one example of how an externalized cost, in this case pollution, is artificially internalized, so that the market price changes accordingly.

2. BACKGROUND: ENVIRONMENTAL DEGRADATION AND ECONOMIC GROWTH

There has been a close historical correlation between economic growth and environmental degradation in that as communities

grow, so the environment declines. This trend can clearly be demonstrated on graphs of human population numbers, economic growth, and environmental indicators. Unsustainable economic growth has been starkly compared to the malignant growth of a cancer 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.

While conventional economics is concerned largely with economic growth and the efficient allocation of resources, ecological/environmental economics has the explicit goal of sustainable scale (rather than continual growth), fair distribution and efficient allocation, in that order. The World Business Council for Sustainable Development states that "business cannot succeed in societies that fail"

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. 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. 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.

3. NATURE AS AN ECONOMIC EXTERNALITY

3.1. Ecosystem services

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. In general, as a commodity or service becomes scarcer 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. As ecosystem services are generally treated as economic externalities they are priceless and therefore overused and degraded, a situation sometimes referred to as the Tragedy of the Commons.

One approach to this dilemma has been the attempt to "internalize" these "externalities" by using market strategies like ecotaxes and incentives, marketable permits for carbon, and the encouragement of payment for ecosystem services. Community currencies associated with Local Exchange Trading Systems (LETS) and Time Banking have also been promoted as a way of supporting local economies and the environment. Green economics is another market-based attempt to address issues of equity and the environment. 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.

3.2. Economic opportunity

Treating the environment as an externality may generate short-term profit at the expense of sustainability. Sustainable business practices, on the other hand, integrate ecological concerns with social and economic ones (i.e., the triple bottom line). Growth that depletes ecosystem services is sometimes termed "uneconomic growth" as it leads to a decline in quality of life. Minimising 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. 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. Research focusing on progressive corporate leaders who have embedded sustainability into commercial strategy has yielded a leadership competency model for sustainability. The expansion of sustainable business opportunities can contribute to job creation through the introduction of green-collar workers.

4. ENVIRONMENTS' SOCIAL DIMENSION

4.1. Social sustainability

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. "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".

4.2. Peace, security and 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. 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. Depletion of natural resources including fresh water increases the likelihood of "resource wars. 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

4.3. 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 and the Millennium Development Goals. 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. 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. 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. 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 populous 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 countries 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.

5. HUMAN RELATIONSHIP TO NATURE

5.1. Background

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.” 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.

Deep ecology establishes principles for the well-being of all life on Earth and the richness and diversity of life forms. This requires 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.

5.2. Sustainability principles

1. Reduce dependence upon fossil fuels, underground metals, and minerals
2. Reduce dependence upon synthetic chemicals and other unnatural substances
3. Reduce encroachment upon nature
4. Meet human needs fairly & efficiently.

One approach to sustainable living, exemplified by small-scale urban transition towns and rural eco-villages, 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 concept of a bioregional economy. 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.

Large scale social movements can influence both community choices and the built environment. Eco-municipalities may be one such movement. 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.

There is a wealth of advice available to individuals wishing to reduce their personal impact on the environment through small, inexpensive and easily achievable steps. But the transition required to reduce global human consumption to within sustainable limits involves much larger changes, at all levels and contexts of society. The United Nations has recognized 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 behaviors and practices to secure our future" 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.

6. ENVIRONMENTAL ECONOMICS AND SUSTAINABILITY ISSUES

6.1. Sustainability

Sustainability is the capacity to endure. For humans, sustainability is the long-term maintenance of responsibility, which has environmental, economic, and social dimensions, and encompasses the concept of stewardship, the responsible management of resource use.

In ecology, sustainability describes how biological systems remain diverse and productive over time, a necessary precondition for the well-being of humans and other organisms. Long-lived and healthy wetlands and forests are examples of sustainable biological systems.

Healthy ecosystems and environments provide vital resources and processes (known as "ecosystem goods and services"). There are two major ways of managing human impact on ecosystem goods and services. One approach is environmental; this approach is based largely on information gained from educated professionals in science, environmental, and conservation biology. Another approach is management of consumption of resources, which is based largely on information gained from educated professionals in economics.

Human sustainability interfaces with economics through the voluntary trade consequences of economic activity. Moving towards sustainability is also a social challenge that entails, among other factors, 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 controlling living conditions (e.g., eco-villages, eco-municipalities and sustainable cities), to reappraising work practices (e.g., using permaculture, green building, sustainable agriculture), or developing new technologies that reduce the consumption of resources.

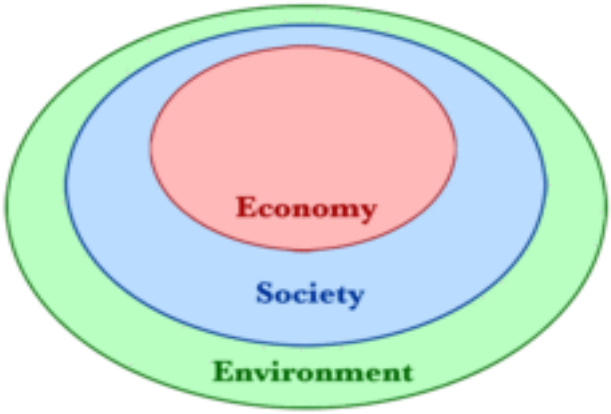

Figure 1: A diagram indicating the relationship between the three pillars of sustainability suggesting that both economy and society are constrained by environmental limits

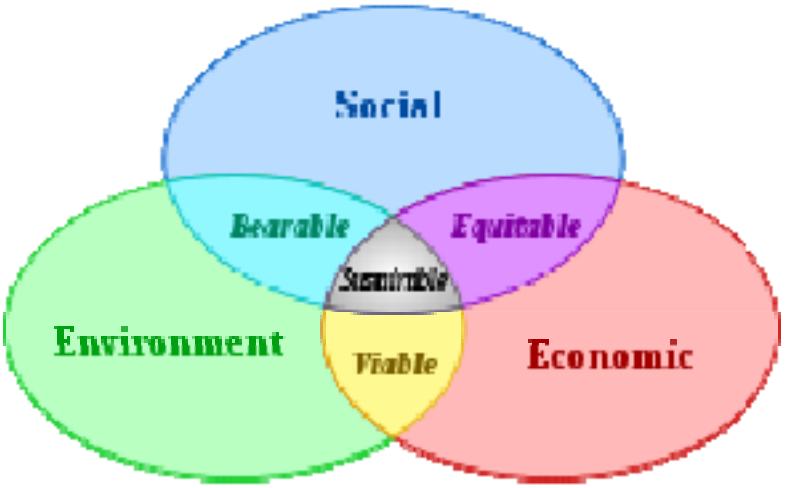

Figure 2: Scheme of sustainable development: at the confluence of three constituent parts.

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.”

At the 2005 World Summit it was noted that this requires the reconciliation of environmental, social equity and economic demands - the "three pillars" of sustainability or (the 3 E's). 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.

The three pillars - or the "triple bottom line" - have served as a common ground for numerous sustainability standards and certification systems in recent years, in particular in the food industry. Standards which today explicitly refer to the triple bottom line include Rainforest Alliance, Fairtrade, UTZ Certified, and The Common Code for the Coffee Community. The triple bottom line is also recognized by the ISEAL Alliance - the global association for social and environmental standards.

The triple bottom line as defined by the UN is not universally accepted and has undergone various interpretations. What sustainability is, what its goals should be, and how these goals are to be achieved are all open to interpretation. For many environmentalists, the idea of sustainable development is an oxymoron as development seems to entail environmental degradation. Ecological economist Herman Daly has asked, "what use is a sawmill without a forest?" 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. This can be illustrated as three concentric circles.

A universally accepted definition of sustainability remains elusive because it is often linked with other concepts such as "sustainable development" or "sustainable agriculture" (often placed in an anthropocentric context). On the one hand it needs to be factual and scientific, a clear statement of a specific “destination”. The simple definition "sustainability is improving the quality of human life while living within the carrying capacity of supporting eco-systems", through 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. The Earth Charter speaks of “a sustainable global society founded on respect for nature, universal human rights, economic justice, and a culture of peace.”

6.2. Sustainability measurement

Sustainability measurement is a term that denotes the measurements used as the quantitative basis for the informed management of sustainability. 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 and other reporting systems. They are applied over a wide range of spatial and temporal scales.

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

6.3. Consumption — population, technology, resources

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.

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

6.4. Human population control

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. 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.

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. 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.

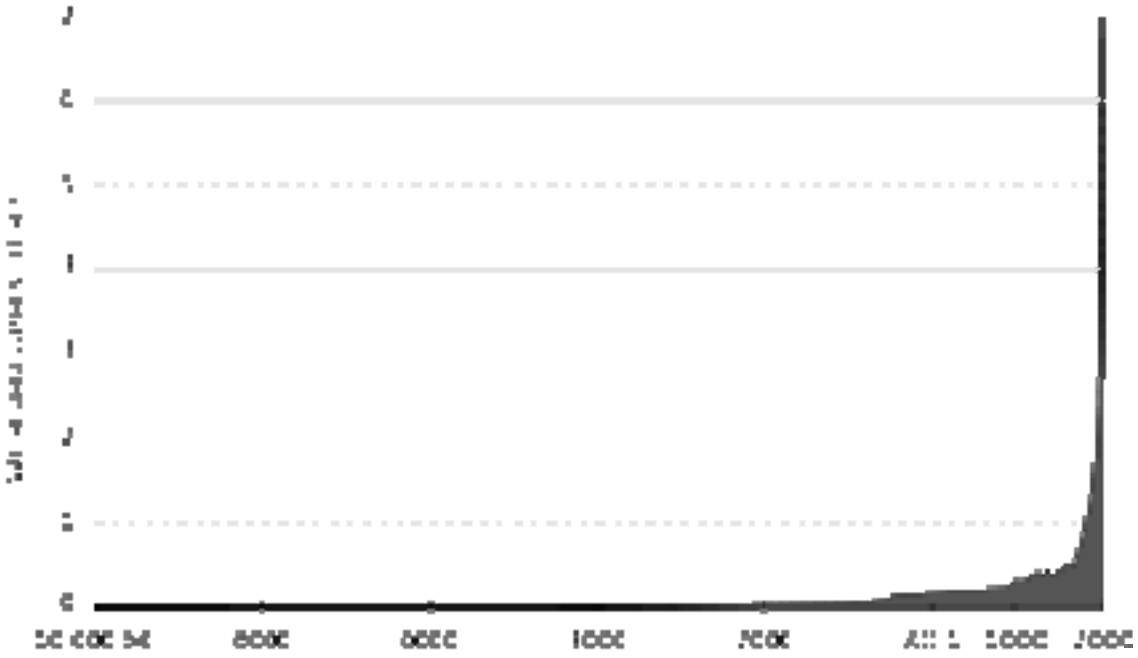

Figure 3: Graph showing human population growth from 10,000 BC – 2000 AD, illustrating current exponential growth.

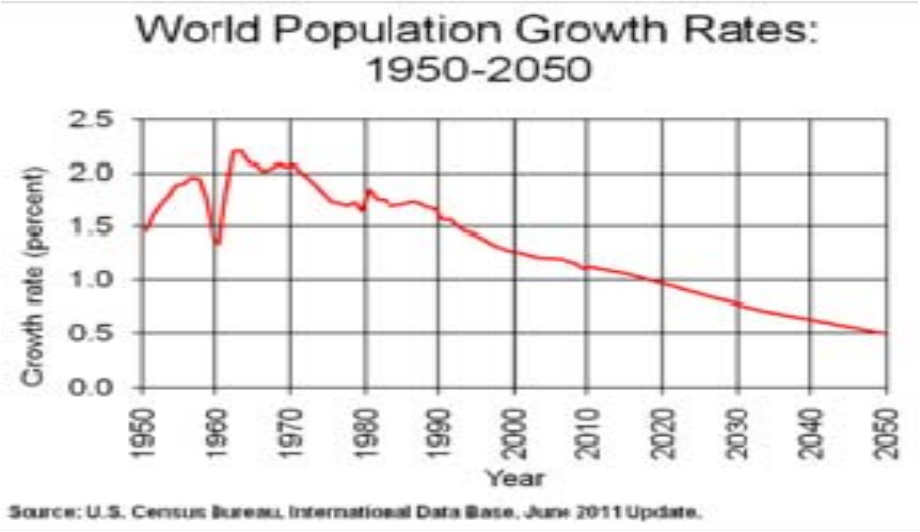

Figure 4: World population growth rate, 1950-2050, as estimated in 2011 by the U.S. Census Bureau, International Data Base.

6.5. Carrying capacity

Scientific evidence 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. An early detailed examination of global limits was published in the 1972 (Limits to Growth), which has prompted follow-up commentary and analysis. A 2012 review in Nature by 22 international researchers expressed concerns that the Earth may be "approaching a state shift" in its biosphere

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). 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).

As always, population growth has a marked influence on levels of consumption and the efficiency of resource use. 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.

7. GLOBAL HUMAN IMPACT ON BIODIVERSITY

7.1. Millennium Ecosystem Assessment

At a fundamental level energy flow and biogeochemical cycling set an upper limit on the number and mass of organisms in any ecosystem. 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.

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.

7.2. 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.

8. ENVIRONMENTAL MANAGEMENT

8.1. Sustainability and 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.

8.2. 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". 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 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.

8.3. 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. 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.

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. Ten per cent of the world's populations – about 600 million people – live in low-lying areas vulnerable to sea level rise.

8.4. 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. At the local human scale, major sustainability benefits accrue from sustainable parks and gardens and green cities.

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. In temperate and boreal regions forest area is gradually increasing (with the exception of Siberia), but deforestation in the tropics is of major concern.

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 and about 20% of its net primary productivity. 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.

9. MANAGEMENT OF HUMAN CONSUMPTION

9.1. Consumption (economics)

The underlying driver of direct human impacts on the environment is human consumption. 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. 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 are important tools for understanding the impacts of consumption. Key resource categories relating to human needs are food, energy, materials and water.

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 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 combusting 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.

9.2. Sustainable energy, renewable energy, and efficient energy use

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. 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.

Reducing greenhouse emissions, is being tackled at all scales, ranging from tracking the passage of carbon through the carbon cycle 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.

9.3. Water resources

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. 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. From 1961 to 2001 water demand doubled - agricultural use increased by 75%, industrial use by more than 200%, and domestic use more than 400% 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

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-industrialised world, concentrating food production in areas of high productivity, and planning for climate change. At the local level, people are becoming more self-sufficient by harvesting rainwater and reducing use of mains water.

9.4. Food and Food security

The American Public Health Association (APHA) defines a "sustainable food system" 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." 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. 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. 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 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.

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.

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.

9.5. 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.

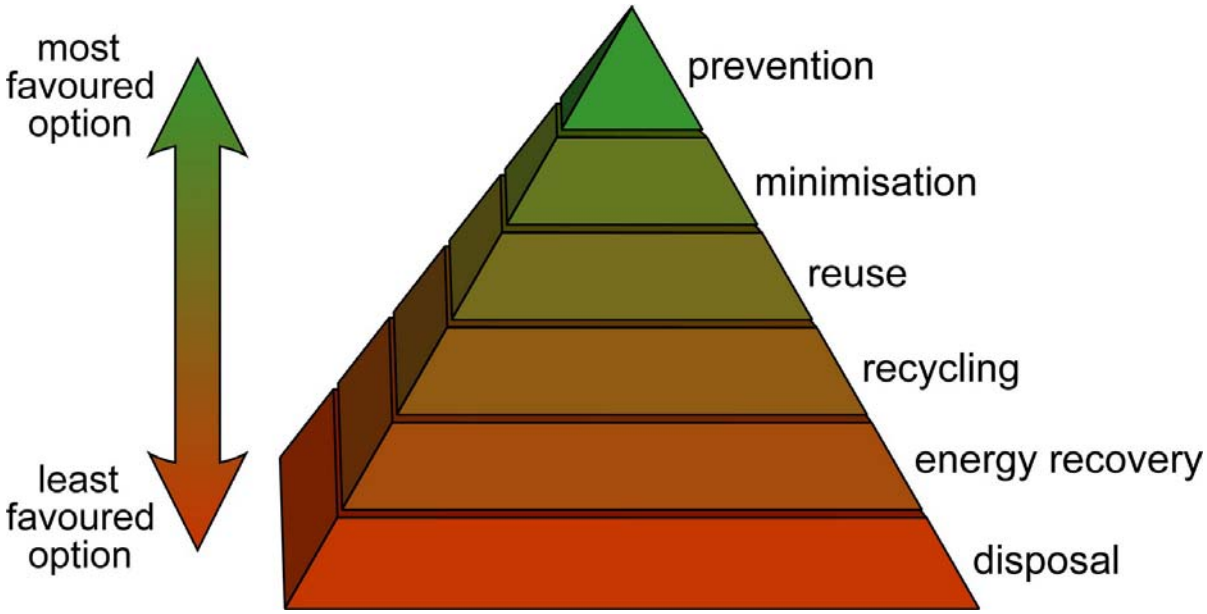

Figure 5: The waste hierarchy

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. 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.

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. This approach is supported byproduct stewardship and the increasing use of material flow analysis at all levels, especially individual countries and the global economy. 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.

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. 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.

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 and ecolabelling. In addition to the well-established “reduce, reuse and recycle,” shoppers are using their purchasing power for ethical consumerism

10. ECONOMIC DIMENSION (CONCLUSION)

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." Sustainability interfaces with economics through the social and ecological consequences of economic activity. 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." However, the concept of sustainability is much broader than the concepts of sustained yield of welfare, resources, or profit margins. 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.

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 favour one political perspective over another but works to minimise 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”

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 behaviour

But the human welfare benefits generated by ecosystem goods and services are both private and public goods made available across a range of temporal and spatial scales, and associated with (or hindered by) a variety of property rights and other institutional arrangements. The resource space can be privately owned, publicly owned by the nation, represent common property or be subject to international treaties and agreements. The gainers and losers in any environmental change situation therefore vary depending on the type and scale of ecosystem service provided, the mix of stakeholders involved and the socio-economic characteristics and the socio-cultural context. This complexity ensures that the political economy of ecosystem conservation will encompass not just efficiency and effectiveness criteria, but also equity, justice and legitimacy criteria together with other ethical concerns.