Environmental Sustainability versus Economic Development

LECTURE NOTES

DEVELOPMENT THEORY AND SUSTAINABILITY

While many people focus on the state of the economy, they often forget that the economy depends on the state of our planetary ecosystem. The economy is a sub-set of the environment and the ecology of resource use. "Ecology" derives from the Greek term Oikos, meaning "house." The ecology of resource use entails the components of equity, environment and the economy. Equity is an ethical issue and requires a fair distribution of resources. The relationship between economic thinking and ecological thinking, however, is less straightforward. Ecologists and economists have fundamentally different perspectives and operate within different paradigms regarding the treatment of the environment, and there are often conflicts between economic indicators and ecological indicators. Fundamentally, ecologists tend to focus on the limits of growth and natural cycles. They believe that economic markets are inadequate, climate is being destabilized, and water tables are falling. Economists believe that there are no limits to economic growth and use linear or curvilinear projections. They have unyielding faith in the free market, global economy, and international trade. Because the resources available in the ecosystem tend to set a ceiling on economic development, we should consider the term "eco-economy" as a better term.

There needs to be paradigm shifts from economic policy to ecological policy, from political economy to political ecology, and from sustainable development to sustainable systems. We are facing an acceleration of growth in human history, including population growth in the billions, increasing incomes, and explosion of technologies. But, where are the resources coming from to sustain this growth? Ecosystems are like an endowment; every time you withdraw resources, you must give back to nature or you deplete the account. Unfortunately, our long term growth is colliding with the natural limits of our ecosystem. Environmental scientists and economists must calculate the real cost of climate disruption, acid rain, and air pollution and factor that into resource extraction and production and service. Slowing down this speeding train requires that social institutions, corporate entities, governments, and consumers work together toward solutions.

THEORIES OF DEVELOPMENT, MODERNIZATION, AND DEPENDENCY

DEVELOPMENT THEORY

Development theory promotes Western models of economic growth, urbanization, and industrialization as the global standard for national progress. To understand Development Theory, it is important to understand the concept of development. Development means to make something better, or to improve upon it. Development does not necessarily mean growth. For example, all people grow from infants, to children, to adolescents and normally stop growing once they reach adulthood. However, people do not stop developing just because they have stopped growing; they continue their education, learn a new trade or hobby, travel, make new friends and so forth. Development is about making changes for the better. The difference between "growth" and "development" is a difficult but crucial concept for sustainability. Development is often considered "quality" growth. However, people need to realize that all growth is finite. We live in a world with

a limited amount of resources: air, water, energy, materials, and land. Many people are beginning to understand that the Earth is a global community and there are limits to the number of people that can occupy the planet can support and to the amount of resources that those people can consume. We need to develop or improve our local, regional and global communities without using up the resources that we have. Development theories can help us conceptualize our situation and gradually move us towards practical applications.

There are two dominant schools of thought in development theory, The "development-from-above" school and the "development –from-below" school. The "development-from-above" school views development as essentially emanating from the growing core of society and spreading to the periphery. This school views development as starting from worldwide demands and critical innovations and filtering down through national, sub-nation, and urban or rural units to society. The "development-from-below" school does not necessarily dispute the influence of development-from-above, but argues that local and regional communities should have control of their own institutions to create relevant changes. According to Glaesar (2000), "development theories traditionally ask how a structured order can be produced and how it was produced historically in any given society or in a set of societies." Socially this process refers to institution building in the civic society, politically to nation building and economically to market building.

MODERNIZATION THEORY

In Medieval Europe, the rise of rationalism and empiricism created scientific theories and technical inventions that initiated a shift towards more secular universalism. This secular universalism eroded the claims of religion and modernism slowly emerged as the new worldview, setting the stage for the great changes of globalization and the Industrial Revolution of the 1800s and 1900s. Currently, modernization is a dynamic, multifaceted process. Its most intense early expression in the West was the transformation of "traditional" societies into "modern" societies through the forces of market expansion and capital accumulation. Modernization was not simply technological change. It also brought the ideas and discourses of progress and development that legitimized the shift for traditional society. Out of modernization came the rise of instrumental rationality, new scientific inquiry, technological development, the rise of the nation-state, industrialization, and significant changes in culture, identity, and the human relationship with the non-human world.

DEPENDENCY THEORY

Dependency theory contends that African and Asian countries became poor as a result of being colonies, while the colonial powers where able to advance at their expense.

ECO-DEVELOPMENT/CO-OPERATION

The new strategy of eco-development and co-operation underlines the importance of global solutions to environmental problems. Eco-development and co-operation are, ultimately, complementary. Eco-development helps developing people meet their needs and improve their lives sustainably, while co-operation finds mutual benefits for both sides. Both foci recognize development is not exclusively economic or material. The notion of "development" should never be confined to the realm of the economic. Eco-development has cultural and ideological aspects and a dominant place among the terms used to describe and maintain sustainability.

Women collecting water with a 5 gallon bucket and a Hippo Roller.
The Hippo Roller carries 24 gallons of water and can be rolled on the ground instead of being carried.

Eco-development/co-operation has a natural resource base, requiring changes in how we currently live. This new strategy requires Northern industrialized countries to reduce resource consumption and assist developing countries of the South in adopting sustainable, resource efficient technologies. These technologies ultimately depend on financial and technical support from the North. An alternative approach is developing eco-parks and eco-tourism industries in the global South.

Our mechanical perception of the biosphere is dangerously superficial, and our continued belief in the possibility of sustainable development based on the growth-oriented assumptions of Neo-Classical economics is an illusion. Now that sustainable development has been embraced by the political mainstream, the concept has been stripped of its original concern for future ecological stability. The traditional process of development onto which sustainability has been grafted concentrates attention on the resource base, and particularly non-renewable resources. The newer sustainability paradigm, by contrast, sees the use of renewable resources as the objective of sustainability. The major threat to the long-term sustainability of the Earth's resources is identified in the key indices of resource degradation, in the loss of soil and water quality, and the inability of the atmosphere to absorb air pollution. The ethical manifestation of ecological co-development/co-operation is contained in the idea of environmental stewardship where human societies are the tenants of the Earth, holding resources on trust for the future. In more technical terms, this stewardship tradition is concerned with sustainable yields from renewable resources, and in placing emphasis on natural capital stocks, rather than on the income flows these can generate for human populations.

APPROPRIATE TECHNOLOGY

Depending on political goals and development objectives, technology can be imported from the global North to the developing South. This reduces development costs, but can be capital intensive. There can also be adverse ecological effects. However, importing appropriate technology that is oriented towards the poor, operates on a small scale, and is environmentally friendly can provide innovative tools that improve self-reliance and labor intensity.

Unfortunately, the technology imported from North to South has not always been appropriate. In development and technology debates, international markets and agencies favor monocultures

in agriculture and their equivalents in the extracting and processing industries, thus preserving the imbalanced economic structures inherited from the colonial period. Over time, monocultures promote ecological destruction and with it, economic problems and social inequality. Development is understood as a process of social, political and economic growth and change. Technologies, like monoculture, disrupt and displace basic needs, such as land, food, shelter, education, health care and energy for the material benefit of a distant minority, leaving the local minority's essential needs unmet. Although development is understood as a process of social, political and economic growth and change, technologies, like monoculture, disrupt and displace basic needs, such as land, food, shelter, education, health care, and energy of the local majority for the material benefit of a distant minority. This imbalance creates underdevelopment and devolution into poverty, injustice, and conflict.

For these reasons, Glaeser (2000) believes the concepts of eco-development and appropriate technologies are important. Both concepts stress endogenous factors and approaches to development. In contrast to early modernization, with the emphasis on industrial development, appropriate technology transfer and eco-development recognizes the importance of the rural sector and takes the provision for basic needs its cardinal aim. In this theory, development and the environment form a dialectical union that preserves social development in the rural poor. While it is sometimes necessary for a developing market to temporarily disassociate from the world market to become self-reliant, once a local economy is stimulated and becomes independent, then countries of the North and South can profit mutually and equally.

GLOBAL DAMAGE TO THE ENVIRONMENT

AGRICULTURE

The Green Revolution in agriculture is associated with economic development in the 1960s. It was initiated by a wave of agricultural research that selectively bred higher-yield varieties of wheat and other basic staple crops. The main new technology of the Green Revolution was hybridized seeds that photosynthesized more efficiently and therefore grew faster, responded more readily to fertilizer and irrigation, were not sensitive to day length and could be grown in different seasons and regions. This new form of agriculture also required new management practices, new infrastructure, pesticides, herbicides, fertilizers, new agricultural machinery, and greater inputs of fossil fuels. With all of the elements in place, new commercial varieties produced significantly higher yields than traditional varieties. Whereas seeds were once collected and planted locally by farmers, they were now increasingly purchased from multinational seed corporations based on crops selected in the laboratory for their productivity and commercial viability. These commercial seeds had been bred from varieties collected from all quarters of the world to improve yield and resistance to insects and pesticides. The new industrial farming technologies, practices and social relations were produced and reproduced through new research and tertiary education institutions, government agencies, new technocratic agents of agricultural modernization, new management systems, credit systems and business practices, and new infrastructures such as railways, roads, and power lines. The methods unleashed by the Green Revolution quickly became global. Agribusiness found the system to highly profitable and expanded food production was essential to the national security of developing nation-states.

Unsurprisingly, critics from the Global South regarded the Green Revolution as a form of First World food imperialism since it created new forms of material dependency. But, the industrialization of agriculture was not an exclusively capitalist development. The Soviet Union applied the same rationale and similar processes to replace peasant agriculture with collective farming. Likewise, in China, Zhou Enlai's "Four Modernizations" campaign in 1963 included agriculture and allowed the purchase of new industrial and agricultural machinery from the West. This modernization program was a direct response to the failure of Mao Zedong's Great Leap Forward campaign, which led to widespread famine and mass starvation in China.

While the Green Revolution worked well for those farmers who enjoyed the appropriate infrastructure and could afford to assemble all the inputs in the new production system, it was devastating for many farmers who lacked the infrastructure, support services, and necessary capital to succeed. Many farmers in developing countries defaulted on their loans and were forced into bankruptcy and increased poverty. In addition, none of the proponents of the Green Revolution had seriously considered the new system's environmental impacts and the implications for biodiversity, such as the loss of aquifers and reduced flow from rivers due to irrigation systems, the eutrophication of waterways from high fertilizer use, and the destruction of habitat from the extensive clearing of land and forest for new crops. Also, by separating animals and crop production and purchasing phosphorus fertilizer, modern agriculture broke the phosphorus cycle whereby animal manure returned phosphorus to the soil to fertilize the next crops. Since phosphate rock is nonrenewable, global supplies of phosphorus fertilizer began to dwindle, driving up the price and creating insecurity in the food markets. Monocultures also proved to be vulnerable to new pests and diseases that could wipe out entire crops. This led to increasing application of pesticides, which led, in turn, to diminishing returns from high-yield varieties, driving up the cost and defeating the purpose of the new agrarian system. Further, no one factored in the production cost of increased dependence on fossil fuels, the loss of carbon sinks from converting forest for agricultural land, or significant methane emissions from livestock.

All of these problems produced a major assault on biodiversity, including the diversity of ecosystems and species but particularly genetic diversity. For example, by the end of the 20th century just 15 crops provided 90% of the world's food energy intake, with just three, rice, corn and wheat providing 60% of the intake (Christoff and Eckersley, 2013). Genetic diversity has declined not only in crops and livestock but also in wild species from the encroach-

ment and fragmentation of wild habitats through land clearing and the building of roads, railways, dams and other infrastructure.

The Green Revolution was launched with good intentions and has succeeded in expanding global agricultural output to feed a growing population. Yet it has come at a considerable cost to global biodiversity and in some cases displaced local food cultures. Despite the many criticisms of the Green Revolution, it is not over. It is simply no longer new or revolutionary, because it is now standard practice. In spite of the concern over the accumulating side effects of the Green Revolution, a "second" Green Revolution is under way as a result of developments in modern biotechnology that has produced "transgenic," "genetically engineered," and "genetically modified" (GM) plant varieties. Modern agricultural biotechnology is qualitatively different from traditional biotechnology as it seeks to cross the species barrier by inserting genes from a foreign species into the cells of a host species in order to change certain characteristics in the host organism. For example, first generation GM agriculture has been mainly concerned with improving crop yields by improving plant resistance to weed-killing herbicides and insect pest. The second generation has been directed toward enhancing shelf life, nutrition content, taste, and color to increase consumer appeal. While the first Green Revolution spread rapidly to both developed and developing countries, the spread of GM agriculture has encountered early and strong resistance in some countries and regions. Although the United States, Canada, Argentina, and China have embraced this new agricultural technology, the European Union, India, and many developing countries have been more skeptical of its benefits and more cautious in granting approval of imports.

INDUSTRY

With the beginning of the Industrial Revolution around 1750, a new social-ecological regime started. The beginnings were small and hardly noticeable by contemporaries of the time. While human history over the past 10,000 years has been a history of agrarianization, the history over the past 250 years has been the history of industrialization. The metabolic profiles of each regime are quite different. In the industrial regime, energy and material use per capita is three to five times higher than in agrarian societies. Urban population densities tend to be three to ten times higher with energy and material use densities ten to thirty times higher than rural societies. The industrial regime operates on finite stocks of non-renewable resources produced by nature at rates close to zero on the human scale. Since 1900, the mass flows associated with fossil fuel use, ores and industrial minerals, and construction minerals has increased more than ten fold while the biomass fraction has shrunk to one-third. The worldwide use of five key materials: cement, steel, paper, aluminum and thermoplastics, has increased four to six fold between 1960 and 2005 and the growth trend continues exponentially (de Vries, 2013).

The world's industrial center of gravity has shifted from Europe, the United States, and later the Former Soviet Union and Japan to emerging economies like China. Some of the typical characteristics of industrial regimes are the delinking between regional biogeography and economic activities except for the exploitation of natural resources such as minerals and fuels. Normally, there is a transition from local and diffused land-based energy sources like wood, wind and water to concentrated and globally traded fossil fuel-based energy carriers. Economic growth is associated with core industrial sectors and the physical throughput of natural resources and raw materials to manufacture capital goods. The social dynamics of industrialization are driven by resources and capital ownership and forces of a technological-industrial complex run by urban elites of bureaucrats, managers, and technocrats. Industry has a tendency towards concentration and homogeneity of economic activities largely driven by economies of scale and scope and preferential attachment mechanisms and continuing competition between traditional communities, nation-states, and private enterprise corporations.

While a new postindustrial regime is emerging around information and communications technologies, large parts of the world are still in the first stages of industrialization. Therefore, it is widely expected that increasing population and economic activity, non-renewable fuel use, and environmental pollution with continue well into the 21st century. In light of these trends, the field of Industrial Ecology offers some tangible solutions for industry, especially in emerging economies. Industrial Ecology seeks a better fit between industry and environment. Ecological engineering can help industry serve society and reduce costs with better environmental interfaces. Polluting waste can be processed to be environmentally beneficial. More of each material cycle can be managed by industry. In place of environmental regulations, tax incentives can make it possible for industries to generate environmental wealth for the public and still compete economically (Odum, 2007).

URBANIZATION

At the beginning of the 21st century, 47% of the world's population was living in towns and cities. The United Nations estimates that by 2030 more than 60% of the world's population will be urban dwellers. In the cities of the developing nations, urbanization will proceed at a slower pace than in the developed world, but the process is already well advanced and by 2030 84% of the

population will live in urban areas. The rate of change and the absolute numbers involved vary from continent to continent, but the overwhelming growth in the developing world is evident. Of the 19 cities with a population of 10 million or more in 2000, 15 are in developing countries. By 2015, 23 cities will have populations over 10 million with 19 being in the developing world. Although such cities illustrate what increased urbanization means in absolute numbers, most of the urban population growth will take place in communities of less than 1 million. Cities of that size will account for 45 % of total urban growth between 2000 and 2015, whereas similar cities in the developed nations will provide only 3% (Kemp, 2004).

Modern urbanization in the developing world is unlike the earlier growth of towns and cities in that it is not driven by industrialization but by natural growth and migration from rural areas. Rather than a pull from industry, migration to urban areas is driven by a push from the countryside where the available land is no longer able to support the rapidly growing population. Unfortunately, moving to the city may not bring improvement in opportunities. Many migrants end up living in poverty in the periphery squatter settlements that are part of all major cities in the developing world. Cities in the developing world also lack the transportation network that allowed the movement from core to periphery in industrial cities, and as a result the core areas are more densely populated. Urban infrastructure put in place when the cities were smaller can no longer cope with the population pressures. Housing is generally inadequate, the provision of services such as water supply and sanitation is lacking and organized waste disposal is often non-existent. With the potential for the spread of disease and less nutritious diets than in rural zones, the urban poor face a life of poverty, pollution, malnutrition, and poor health. This situation can only get worse as the world's urban populations continue to rise.

We tend to think of cities as sites of intense consumption, suffering under the sheer weight of people, buildings, traffic and pollution, but contrary to popular opinion, mass migration could be a good thing. Optimists see the problems being solved by cities' other qualities as centers of innovation and places that can easily learn from one another. Urban farms, smart grids, rooftop solar power, and rainwater catchment can be helpful in achieving urban sustainability. Large cities with little existing infrastructure may be able to move directly to new and greener ways of urban planning and development. They can turn ramshackle, unlicensed settlements into urban areas integrated into city life. Each of those hundreds of cities with less than a million people can be a site for new experiments in urban living, with planners, architects, engineers, and administrators staying alert for the best solutions. If so, future life in cities is a hopeful prospect.

PROCESS OF GLOBALIZATION

Globalization is the extension of social and ecological relations across world space. More specifically, globalization is a set of processes that are producing specific kinds of global interconnectedness and interdependence between individuals, communities, and countries, while at the same time contributing to a heightened social reflexivity about its impact on local communities. Christoff and Eckersley (2013) suggest "globalization is typically discussed as if it were a singular or unified phenomenon, and is often reduced by some to an ideology of neoliberalism or process of Westernization, [but] on closer inspection it emerges as a complex, uneven, and often contradictory set of processes operating in a range of different intersecting domains, producing not only homogenization and heterogenization but also hybridization. Identifying these different domains, the different logics by which they operate, and how they interact and shape each other is a necessary first step in disentangling the relationship between globalization and ecological change."

ECONOMIC GLOBALIZATION

Economic globalization in its current dominant form refers to the spatial expansion and deeper integration of capital markets, facilitated by the removal of border restrictions on the movement of money, materials, and goods. It encompasses the expanding and accelerating trans-border flows of goods, services, investments, and financial transactions. During the production process, global supply chains take advantage of economies of scale and efficiencies in different locations. The rise of corporations with operations in many different countries and localities has extended and intensified commodification and mass consumerism.

SCIENTIFIC AND TECHNOLOGICAL GLOBALIZATION

The spread of new technologies is often regarded as a facet of economic globalization, but these technological developments are the fruits of a broader and much longer process of scientific inquiry with its own dynamic and transnational character. Scientists band together to exchange and test ideas through global networks. The scientific method of inquiry transcends nationality and many research projects such as geology, chemistry, and climatology are genuinely global in scope and planetary in concern. Scientific discourses play an important role in the detection of ecological problems and setting the agenda for environmental policy and the process of monitoring major environmental regimes.

POLITICAL GLOBALIZATION

The political dimension of sustainability comprises two separate, but related, elements: the weight to be attached to human agency and social structure in determining the political processes through which the environment is managed; and the relationship between knowledge and power in popular resistance to dominant world views of the environment and resources. In both cases it is useful to draw on a new body of emerging social theory.

An examination of the way power is contested helps us to explain human agency in the management of the environment as well as the material basis of environmental conflicts. In this sense it is useful to distinguish between the way human agents dominate nature in what we can term "allocative resources" and the domination of some human agents by others or "authoritative resources." Environmental management and conflict are about

both processes: the way groups of people dominate each other, as well as the way they seek to dominate Nature. Not surprisingly the development, or continuation of more sustainable livelihood strategies carries important implications for the way power is understood between groups of people, as well as for the environment itself. The "Green" agenda is not simply about the environment outside human control; it is about the implications for social relations of bringing the environment within human control.

While human agency is important in sustainable development, many observers overlook the relationship between knowledge and power and its role in the political dimension of sustainability. As we shall see in a moment, the consideration of epistemology in sustainable development carries important implications for our analysis. Epistemology refers to the way people make and authorize knowledge and it strikes at the cultural roots of quite different traditions of indigenous knowledge. It is also important to emphasize that knowledge and power are linked.

CULTURAL GLOBALIZATION

Globalization has increased general awareness of cultural diversity, while also facilitating new forms of cultural homogenization and hybridization. The increasing dominance of particular languages, most notably English, and the spread of both high and popular culture has prompted reactive processes of re-traditionalization against the forces of homogenization. Simultaneously, cultural globalization has facilitated the spread of human rights norms and a cosmopolitan ethic and social identity. This global human identity declares that we are all citizens of the world and of equal worth regardless of nationality, religion, gender or race. This emergent global social awareness is accompanied by the development of a "planetary consciousness"' that includes awareness of the diversity and richness of the Earth's biodiversity as well. We are more knowledgeable about the complexity of its ecosystems and atmosphere and the stresses human activities place on the natural environment.

MAPPING SUSTAINABLE DEVELOPMENT

The concept of sustainable development represents a shift in our understanding of humanity's place on the planet, but it is open to interpretation and is frequently understood as anything from an almost meaningless generality to a crucial concept for humanity. Whatever view is taken, it is clearly an area of contention. Recognizing the deep debates and ambiguities about the meaining of sustainabable development, we will use the phrase "sustainable development" to describe attempts to combine concerns with the environment and socio-economic issues.

In his widely used taxonomy of environmental views, O'Riordan (1989) describes positions ranging from the strong ecocentric to the strong technocentric. He also argues that these views often have characteristic socio-economic viewpoints; ecocentrics tend towards social and economic equity and redistribution while technocentrics are more likely to support the economic and political status quo.

To provide a generalized view of the trends within the sustainable development debate, O'Riordan's original mapping can be expanded by considering environmental and socio-economic views on two separate axes, illustrated in Figure 1: Mapping of views on sustainable development (Hopwood et al., 2005). The socio-economic axis plots the level of importance given to human well-being and equality and the environment axis plots the priority of the environment from the low environmental concern of techno-

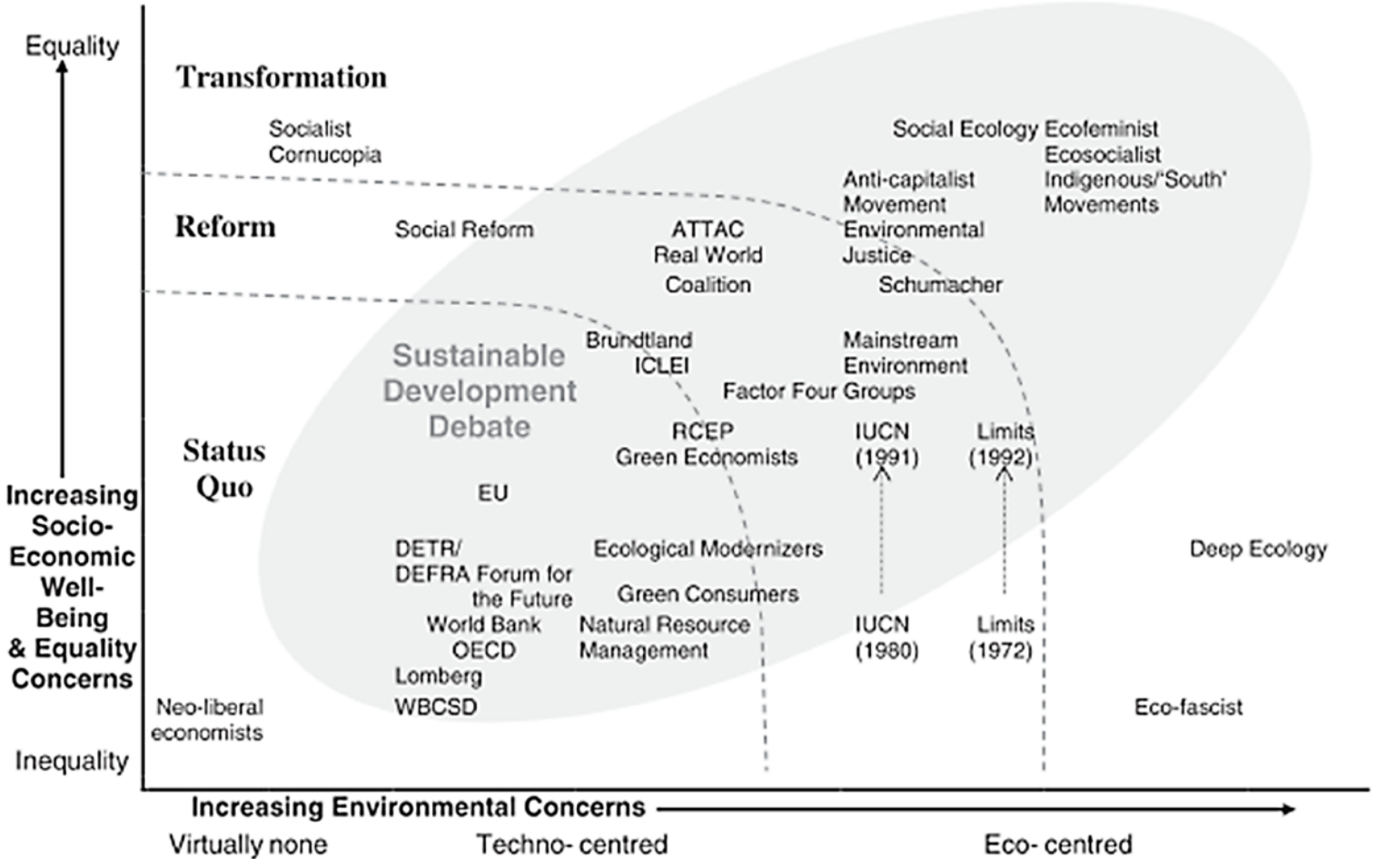

Figure 1: Mapping of views on sustainable development (Hopwood, et al., 2005)

centric views, to high priority of ecocentric positions. The central shaded area of the map indicates the range of views within the sustainable development debate, combining socio-economic and environmental issues. This map also represents three broad views on the nature of the changes necessary in society's political and economic structures and human–environment relationships to achieve sustainable development: 1. The status quo which holds that sustainability can be achieved within our current structures; 2. Reform which holds that fundamental reform is necessary but without a full rupture with the existing arrangements; and 3. Transformation which holds that the roots of the problems are the very economic and power structures of society and that these need a radical transformation.

This is inevitably a broad conceptual framework, rather than a precise mapping, and exact locations are open to challenge. All classification into groups is a simplification and there can be debate about where the boundaries are drawn as well as how sharp or blurred they are. Individuals and groups change their views over time and there are also major debates within all these outlooks. Nevertheless, this map is useful in the way it represents the possible combination of views and the corresponding political narrative.

APPROACHES TO SUSTAINABLE DEVELOPMENT

STATUS QUO

Supporters of the status quo recognize the need for change but see neither the environment nor society as facing insuperable problems. Adjustments can be made without any fundamental changes to society, means of decision making or power relations. This is the dominant view of governments and business. Supporters of the status quo are most likely to work within the corridors of power talking with decision makers in government and business. Development is identified with growth and economic growth and is seen as part of the solution. They argue that business is the driver towards sustainability. Increased information, changing values, improved management techniques and new technology all operating through the market are the best means to achieve sustainable development.

Most Ecological Modernizers support the status quo, although some see the need for reform. They support the market, "the key to ecological modernization is that there is money in it for business," (Dryzek, 1997, p. 142) and technology in a partnership of government, business, moderate environmentalists and scientists with much less concern for equity, justice or human well-being. Supporting the reduced role of government, supporters of the status quo are reluctant to use laws and regulations. Instead, consumer power, informed about sustainability issues and based on lifestyle choices, will combine with "green" capitalists who practice "corporate citizenship" and ethical business to achieve sustainable development. It is assumed that the existing governmental and commercial systems can be nudged towards improvements with use of management techniques such as environmental impact assessment (EIA), eco-management and audit system (EMAS), cost/benefit analysis, best available techniques not entailing excessive cost (BATNEEC) and best practicable environmental option (BPEO).

In parallel, technical economic tools such as modest environmental taxes, pollution trading permits and ethical shares will encourage the move to sustainable development. Most supporters of the status quo have a weak commitment to environmental sustainability.

REFORMIST

Those who take a reform approach accept that there are mounting problems, being critical of current policies of most businesses and governments and trends within society, but do not consider that a collapse in ecological or social systems is likely or that fundamental change is necessary. They generally do not locate the root of the problem in the nature of present society, but in imbalances and a lack of knowledge and information, and they remain confident that things can and will change to address these challenges. They generally accept that large shifts in policy and lifestyle, many very profound, will be needed at some point. However, it is assumed that these can be achieved over time within the present social and economic structures. The key is to persuade governments and international organizations, mainly by reasoned argument, to introduce the needed major reforms. They focus on technology, good science and information, modifications to the market and reform of government. This group covers a range of people, some in government and public agencies, but it is largely dominated by academics and mainstream NGO experts. Green economists argue that the market needs modification to redress market failure and regulation to achieve ecological sustainability.

Reformers recognize that government has a key role in moving towards sustainable development, as business will need pushing, and in some cases controlling, taxes and subsidies changing, targeting of research and disseminating of information. The mainstream environmental groups such as Friends of the Earth, Greenpeace, WWF and Sierra Club are largely in the reform group and increasingly have moved from grass roots activism and mass protest to political lobbying and working with business and government.

TRANSFORMATIONIST

Transformationists see mounting problems in the environment and/or society as rooted in fundamental features of society today and how humans interrelate and relate with the environment. They argue that a transformation of society and/or human relations with the environment is necessary to avoid a mounting crisis and even a possible future collapse. Reform is not enough as many of the problems are viewed as being located within the very economic and power structures of society because they are not primarily concerned with human well-being or environmental sustainability.

Deep ecologists' primary concern is the environment, with the emphasis on the intrinsic value and needs of nature and the environment, while human needs come very much second. In contrast to deep ecologists, socialist cornucopians, prioritize the need for social transformation to overcome social and economic inequality. Some hardly address environmental issues, believing that human skills, freed from capitalism, can overcome all problems. Some, such as grass roots environmental justice and indigenous environmental movements, may not use the same vocabulary of

sustainable development as used in official and academic circles but are addressing the issues of how to live within the environment without great inequality or poverty. Transformationists see the fundamental problems as rooted in our present society, which is based on the exploitation of most people and the environment by a small minority of people.

Ecofeminists see a relationship between the degradation of the environment and the subordination of women. Ecosocialists argue for the need to change material conditions and the social structure of society to overcome both environmental crises and injustice.

In the developed world as well, there are growing struggles for environmental justice, which unite social and environmental issues. Although too often ignored by mainstream environmental groups, these actions, especially of the poor, racial minorities and those without political power, all point to a more sustainable society. Hofrichter (1993, pp. 4–5) states that "Environmental justice is about social transformation directed toward meeting human need and enhancing the quality of life – economic equality, health care, shelter, human rights, species preservation and democracy – using resources sustainably" and that achieving it "demands major restructuring of the entire social order."

WEAK SUSTAINABILITY AND STRONG SUSTAINABILITY

The debate currently focuses on the substitutability between the products of the market economy and the environment—"manufactured capital" and "natural capital"—a debate captured in the terms weak vs. strong sustainability. It is increasingly clear that the criteria for weak sustainability, based on the requirements for maintaining economic output, are inconsistent with the conditions necessary to sustain the ecosystem services of the natural world. Weak and strong sustainability each have their own specific valuation approach and thus different ethical perspectives. Within the field of economics, this search for an operational definition of sustainable development has led, among many other contributions, to the concepts of strong and weak sustainability.

Under the strong sustainability criteria, minimum amounts of different types of capital (economic, ecological, social) should be independently maintained, in real physical/biological terms. The major motivation for this insistence is derived from the recognition that natural resources are essential inputs in economic production, consumption, or welfare that cannot be substituted for by manufactured or human capital. A second possible motivation is quasi-moral, namely, acknowledgment of environmental integrity and "rights of nature." A third is simply risk mitigation.

In all three cases, it is understood that some environmental components are unique and that some environmental processes may be irreversible (over relevant time horizons). "Very strong" sustainability, as supported by the deep ecology movement and those who believe in the "right-to-life" of other species, would then imply that every component or subsystem of the natural environment, every species, and every physical stock must be preserved. This criterion seems impossible, for three reasons. The first is probably sufficient: the dependence of our current industrial economy on primary resources. The second reason is that species and ecosystems are subject to continuous processes of natural change, and while human activity accelerates some of these processes and inhibits others, humans are, at the end of the day, a part of nature. A third reason is legal and philosophical: if other species have absolute rights, as argued for by some, those rights must contradict other rights, especially property rights, already enshrined in law and custom.

A compromise version of strong sustainability focuses on ecosystems and environmental assets that are critical in the sense of providing unique and essential services (such as life-support) or unique and irreplaceable services. Strong sustainability regards natural capital as providing some functions that are not substitutable by man-made capital. These functions, labeled "critical natural capital," are stressed by defining sustainability as leaving the future generations a stock of natural capital not smaller than the one enjoyed by the present generation. That is, sustainability is viewed in terms of non-decreasing natural capital. Counter to this concept, is the concept of weak sustainability. Weak sustainability sets no restrictions on the degree of substitutability between natural and manmade capital, thus natural capital receives no special treatment. Consistent with this interpretation, Pearce and Atkinson (1993) present a weak sustainability index as an economic indicator of sustainable development. The weak sustainability index proposed is defined as the difference between the savings rate and the sum of the depreciation rate of natural and man-made capital. That is, an economy is considered to be "weakly" sustainable if and only if the weak sustainability index is greater than zero.

The strong and weak concepts just outlined can be considered to represent two opposing ends in the quest to give a workable dimension to sustainability.

On the other hand, the concept of sustainability arose from a much broader concern about the conflicts between economic activity and the environment, with special emphasis on inter- and intra-generational equity. That is, the study of sustainability includes a strong emphasis on distributional issues. Thus, even though both growth theory with exhaustible resources, and the analysis of sustainable development share some common ground, the focus of the latter goes far beyond analyzing the conditions that can guarantee constant consumption per capita into the future.

ECONOMIC THEORY

UTILITY AND SUBSTITUTION

The opposition between weak and strong sustainability has been reduced to the distinction between substitution and complementarity of natural and manufactured capital. This distinction has often been discussed in the context of production processes. However, the distinction also applies to consumption and individual welfare. Economic theory begins with the notion of "economic man" or Homo economicus. Economic man enters an exchange market with an ordered set of conscious preferences for goods and services, which is assumed to be fixed and stable over time. There is no explicit notion in standard utility theory of humans as biological beings whose survival depends on harvesting biological products for food and other purposes. For example, our direct dependence on agriculture, in turn, results in an indirect dependence on the hydrological cycle, several nutrient cycles (C, N, S, P), the ozone layer for protection against UV radiation and a stable climate and biophysical environment.

Another common assumption is that preferences are fixed. However, there is evidence that preferences are changing and influenced in a co-evolutionary way by culture and nature. Actually, it does matter what we believe. Our preferences, and our actions based on those preferences, have real consequences in the phys-

ical universe of which we are a part. Humans may "prefer" to use fossil fuels rather than solar energy, they may "prefer" to trade the Earth's biological diversity for consumer goods, but acting on these preferences will change the physical world we live in, probably for the worse. Such an outcome would presumably not be preferred. In fact, preferences in the real world can be inconsistent, as several well known paradoxes demonstrate. In reality, most people do not know what they prefer in many situations, because they do not know the whole range of possible choices, still less the consequences of the possible choices. In fact, the consequences may well be unknowable or incalculable. This is certainly the case for many long-term environmental policies.

VALUATION OF "NATURAL CAPITAL"

The relationship between valuation and sustainability has not received much attention. Valuation theory suggests that under weak sustainability the value of an environmental service can, under certain conditions, be approximated by the price of a market good that is a (close) substitute in production or consumption. Strong sustainability implies a complementary relationship between an environmental service and a market good in production or consumption, from which a shadow price can be derived (as long as nonuse values are zero). Another approach to link sustainability and values is to look at the costs of unsustainability. In practice, the depreciation of natural capital is quantified only for market-priced extractive resources such as forest products, fish or minerals. Since there is no credible basis for assuming that human-made or human capital can substitute for essential ecosystem services such as these, the notion of weak sustainability can only be used as a negative indicator. That is, if the weak sustainability criterion is violated, our current socioeconomic system will not survive anyway.

In particular, the study by Costanza et al. concluded that the annual global value of ecosystem services is between $17 trillion and $54 trillion, with a "most likely" value of $33 trillion. Clearly we cannot meaningfully quantify the depreciation of an infinite quantity by using fractional rates. However, the real depreciation loss is still finite near the margin, at least as long as the biosphere does not collapse. The main point of the exercise would be to estimate the rate of increase of depreciation as the system is perturbed further and further away from its historical co-evolutionary equilibrium state.

The continuing growth of Net National Product (NNP), defined as Gross Domestic Product (GDP) minus capital consumption, or capital allowance is commonly seen as total output of goods and services by the economy. It is often interpreted as the sum of returns to the factors of production, namely natural resources, labor and capital stock. Thus, sustainability is basically seen by neoclassical economists as a problem of managing a nation's portfolio of capital to maintain it at a constant level, either in toto or per capita. It includes natural capital, in principle, but it also allows for virtually unlimited substitution between human-made and natural capital.

NATURAL SCIENCE PERSPECTIVES

Preservation of the physical magnitude of nonrenewable mineral resources would mean leaving them unused. One can interpret this criterion as derived from physical and ecological constraints or carrying capacity receiving priority over everything else. Many ecologists would support the idea that environmental sustainability is mainly a matter of stability, resilience, and biotic diversity. Stability is defined at the level of biological populations. In other words, variables return to equilibrium values after perturbation. Resilience (resistance to change, or robustness) is defined at the system level and refers to maintenance of organization or structure and functions of a system in the face of stress. Resilience can be considered as a global, structural stability concept, based on the idea that multiple locally stable ecosystem equilibria can exist. In other words, the stability of a local equilibrium of a system implies resilience of the respective system, but resilience does not necessarily go along with the stability of each local equilibrium. Sustainability can thus be directly related to resilience, in the face of ecosystem stress relating to human influences.

In order to be able to deal with stability and uncertainty in a way consistent with ecological theory, integration of economic and ecological models is necessary. Unless externalities cover dynamic impacts, including evolutionary effects of activities and decisions made now, "internalization" or "optimization" of such externalities is inadequate to realize environmental sustainability. This perspective can be linked to the one of strong sustainability, by recognizing that maintenance of natural capital does require a precautionary approach which takes safety margins into account, as stability is not guaranteed by operating at the margin of optimal levels of capital.

Natural sciences, in particular ecology, and economics have different interpretations of sustainability. The differences seem to derive from the distinct focal points of each. The economic approach focuses on long-term allocation of capital on the basis of dynamic macro-level optimization models. Uncertainty is reduced to risk. The ecological approach emphasizes pure uncertainty and surprises with micro-level descriptions of ecosystem dynamics. In terms of its implications "weak sustainability," which is directly linked to the growth theory approach, is further away from the ecological sustainability than the "strong sustainability" approach. Nevertheless, the latter two focus on different aspects, namely, ecosystem resilience and complementarity of economic and ecological systems, respectively.

E.O. WILSON

Famed biologist E. O. Wilson lists several qualities of good theory in general and mathematical models in particular. Among these is "consilience," that is, "Units and processes of a discipline that

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conform with solidly verified knowledge in other disciplines have proven consistently superior in theory and practice to units and processes that do not conform." The economic notion of weak sustainability does not pass the test of consilience with the established laws of biological and physical science. Weak sustainability cannot be reconciled with accepted knowledge from other sciences or even sub-disciplines within economics, with respect to the following points:

1. The economic characterization of preferences emphasizing substitution between consumed goods and services is inconsistent with accepted findings and principles from psychology, biology, and is at odds with empirical results from environmental economics, in particular in economic valuation studies.

2. The foundation of weak sustainability developed in economic growth theory was formulated explicitly for nonrenewable resources, not for complex biological systems. In ecological systems sustainability is related to resilience to perturbations. Moreover, the tools of growth theory—deterministic dynamic optimization models with one dynamic equation describing the environment—are too rough to incorporate scientific findings describing living evolutionary systems. Therefore, growth theory cannot offer a complete, and perhaps not even relevant, perspective on sustainability.

3. Production functions in the standard analysis of economic growth and environmental sustainability assume unlimited substitution options in physical terms. In many cases the results cannot really be interpreted, due to the fact that there is no clear relationship between physical and value units—for process inputs and outputs.

4. Whereas global sustainability and sustainable development have received an enormous amount of attention, their implications for open systems like regions and countries have not been dealt with systematically. The large and growing literature on international trade and environment adopts essentially a static perspective, focusing mainly on policies to deal with "externalities."

Regional and national sustainability should be consistent with global sustainability. Their analysis requires an integration of insights in growth theory, international trade theory, resource economics, and ecology. No one has yet succeeded to doing so, and it seems likely that analytical approaches will fall short in this respect. Moreover, possibly the various sustainability criteria differ in terms of spatial implications. For the present, we pass on the most interesting question, which might be for what questions is a weak sustainability test adequate, and conversely, for what questions must we adopt a stricter test?

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