Introduction

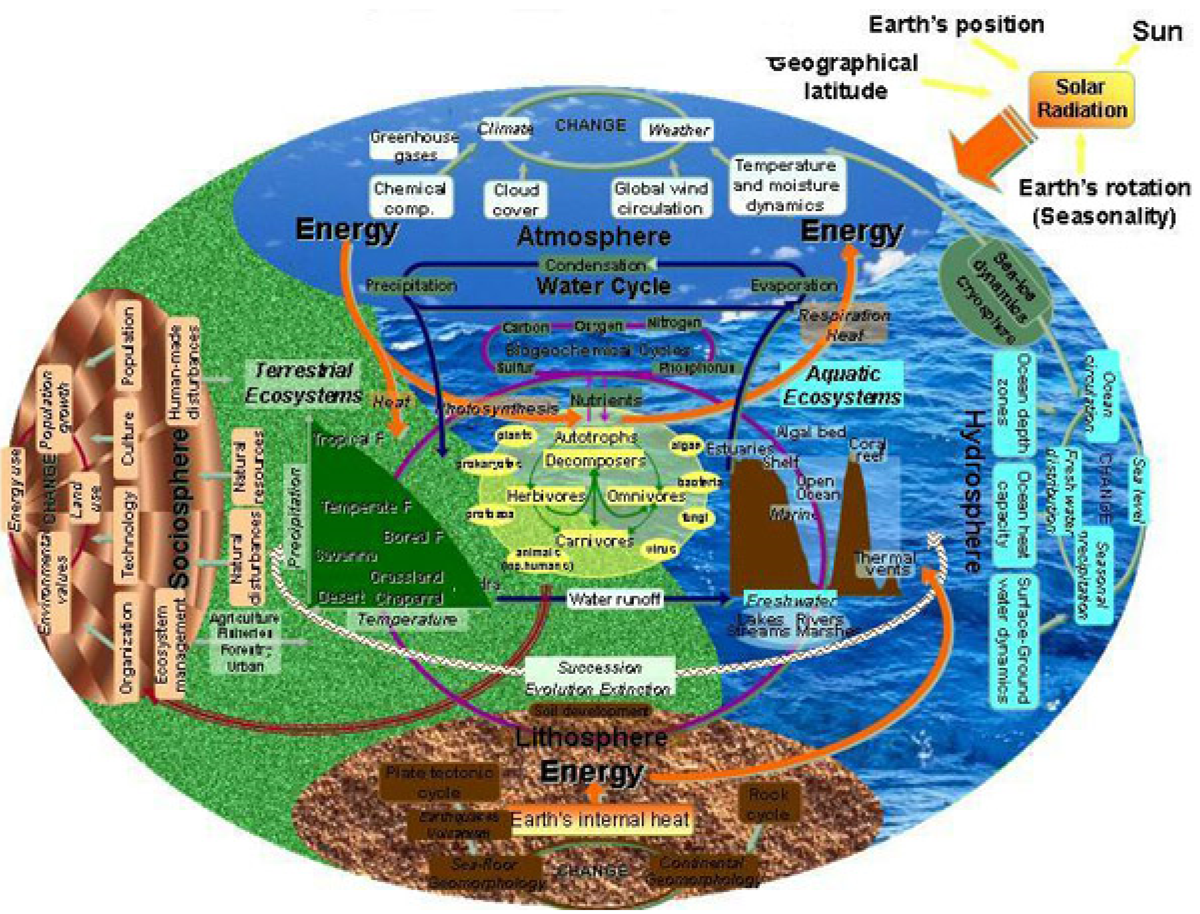
Sustainability as a Social Project

This is a handbook *to* sustainability—a term about which there is much definitional contestation even as there is much agreement that it needs to be achieved—organized around the concept of "problem-solving," and not merely description. There is a broad set of issues that involve the relationship between the Earth's "ecosphere"—the sum of the planet's physical and biological systems—and humanity's "sociosphere"—our collective historical reshaping of the ecosphere and our construction of technological civilization. To a growing degree, these relationships are becoming dysfunctional in ways that we call "problems." Why they are labeled in this way, and who defines something as a problem, is a question we leave until later. For now, we can understand a "problem" as a large-scale contradiction between the social organization of human activities and institutions and the material world on which those activities and institutions are based. In some renderings, such contradictions are described as involving relations between "nature" and "culture." Following the recognition that nature and culture are too deeply intertwined to be easily separated, we make this distinction by using the terms *ecosphere* and *sociosphere* (Fig. I-1).

What types of dysfunctions do we have in mind? Consider climate change as an example. Given the gradual accumulation of data, both empirical and analytical, it has become progressively more difficult to deny that human activities are leading to significant changes in the Earth's climate. The actual

Fig. I-1: The ecosphere & sociosphere

Source: http://www.davidzaks.com/antarctica/pages/systemscience.htm



changes, and their effects on human societies, remain difficult to specify precisely but we can say, with some certainty, that major restructuring of the sociosphere will be necessary if we are to avoid the worst impacts. The Intergovernmental Panel on Climate Change, a project involving thousands of scientists and policymakers, which issues a comprehensive report on climate science at five-year intervals, has proposed that the world's richest countries will need to reduce their greenhouse gas emissions by as much as 75-80% over the coming century in response to climate change. This will limit the global average temperature increase to 2ºC/4ºF, although it will not prevent major impacts around the world, many of which may well result in serious transformations of both the ecosphere and socioshpere. Until now, even relatively minor reductions in greenhouse gas emissions—on the order of 5-10%—have proved impossible to achieve, so it is clear that larger reductions will require concerted governmental planning and action, as well as significant change in the ways people behave, in both rich and rapidly-growing countries.

Although many believe (and hope) that new technologies, geo-engineering and carbon taxes can make such restructuring and reorganization unnecessary, experience suggests that human social systems and associated behaviors and practices are not so easily changed. Moreover, many of these social systems and practices are organized around extensive and costly infrastructures—think here of the automobile and its growing numbers around the world, especially in India and China—on which billions rely for mobility and livelihood and which deeply-vested interests—oil companies, auto manufacturers, commuters—are loathe to give up or reduce. A large-scale shift to mass and rapid transit systems, linked to extensive transformation of urban areas, could significantly reduce the environmental impacts of "automobility," but these are expensive to construct and operate, constrain our "freedom to travel," and can be unpleasant to use, especially if not maintained and overloaded. Moving large numbers of people from cars and suburbs into buses, trains and more densely-populated spaces is, thus, not only a matter of replacing old infrastructure with new, it also involves getting those large numbers to willingly change their habits and practices, to accept more crowded communities and to make mass transit easy to use, when absolutely necessary to do so.

Solving the automobility "problem" is not only a matter, then, of building; we also have to make sure that people will come. And making sure they will come requires not only civil but also social engineering. In the United States, this last concept is generally regarded with some horror, for it reeks of government propaganda, the "nanny state" and even "socialism." We should recognize, however, that social engineering is a commonplace in our societies, even those in which freedom is paramount; after all, what is advertising except the attempt to shape the preferences, desires and consuming practices of large numbers of people? Social engineering for totalitarian purposes and objectives is clearly undesirable; social engineering in order to save both humanity and the planet does not look quite so horrific. In other words, "solving" the climate problem is as much about understanding the intersection of our technological capacity to shape and alter the ecosphere as it is about comprehending how and why the sociosphere is the way it is and how those technologies can be designed and implemented in ways that can and will lead to the necessary changes in human civilization and the sociosphere.

This is why this introductory chapter to the handbook is called "sustainability as a social project." A "social project" is a complex assemblage of things, institutions, beliefs and practices and people organized and operated to meet a particular human need or demand. This does not imply that direct intentionality or functionality were in the minds of an assemblage's "designers," although various elements were clearly designed with both in mind. Indeed, one of the notable features of a social project is that there are few, if any, identifiable individuals who sat down and sketched out the form and requirements for a particular assemblage. To be sure, we can point to prominent and high-profile people who played a major role in bringing the project into being—for example, Henry Ford in bringing the automobile to the mass public or Robert Moses in shaping contemporary New York City—but, for the most part, assemblages are the result of many smaller decisions that aggregate to what is now recognized as a single, if sometimes dysfunctional, whole. Again, consideration of automobility makes clear that an intelligent designer would probably follow a very different route in planning such a social project, were she tasked with doing so today.

"Sustainability" is a social project of social projects, which is how this handbook is organized. Although it is probably impossible to design a prospectively "intelligent" path to sustainability, we nonetheless have the benefit of research, experience and hindsight that permits us to understand how social projects come to be. Such social histories can be trolled for useful information that can be applied to the sustainability project. For example, the energy crises of the 1970s provide critical insights into the effects of high energy prices on policies, politics and practices (not that we seemed to have learned from them). While virtually all of the social sub-projects making up the larger sustainability project intersect one another—water is also about energy, climate, buildings and food—it is easier to treat them individually and note how, through those intersections, the sub-projects affect each other. As we shall see, working through these projects will require some knowledge of physical, biological and chemical processes, their magnitude and measurement, and associated units, quantities and calculations as well as familiarity with the social science that addresses what people think and believe, how they behave, why they are reluctant to change what they do and how they might be induced to change, both individually and in groups.

Box I-1: Throughout this book, you will find boxes, like this one, that will provide additional information, statistics, equations and other tools for understanding sustainability problems and addressing them. These boxes are well-worth reading, and returning to, although they should not interrupt the flow of the main text.

Defining sustainability

Where do we begin? The concept of "sustainability," as we use it in this book, was coined during the 1970s, a decade when heightened concern about the environment combined with worries that global supplies of mineral resources were being depleted. At that time, the primary concern of those writing on sustainability was the relationship between population growth, industrialism and resource supplies. During the 1980s, the term "sustainable development" became popular, culminating in *Our Common Future* (1987), a report by the World Commission on Environment and Development (aka, the Brundtland Commission), according to which:

Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs. It contains within it two key concepts:

- the concept of *needs*, in particular the essential needs of the world's poor, to which overriding priority should be given; and
- the idea of *limitations* imposed by the state of technology and social organization on the environment's ability to meet present and future needs (p. 43).

The concept of sustainable development had, at its heart, a critical contradiction: the Commission envisioned significant growth in the world's economy, by a factor of five to ten, in order to address simultaneously the problem of global poverty and the need for a significant reduction in resource consumption and pollution in order to protect the earth's environment. How the first goal could be squared with the second was left largely to the future; *who* would need to reduce their resource consumption was a political hot potato that no one wanted to touch. Unfortunately, during the 1980s and 1990s, both "sustainable development" and "sustainable" were attached to all kinds of things and processes in order to claim that they would, and could, continue indefinitely. Thus, rather than speaking of a "sustainable economy," people began to talk about "sustainable economic growth," and the term was even applied to military matters. As a result, sustainability lost much of its definitional and practical utility.

During the first decade of the 21st century, however, "sustainability" came (back) into vogue. Although there remains considerable reluctance to define it, and frequent arguments about what constitutes it, people using the term seem satisfied with a general sense that it applies to both social and ecological matters, and includes a significant element of social and environmental justice, as well. In practical terms, sustainability has come to mean (1) development and deployment of new technologies that are "green" and do not require individuals to make major lifestyle changes; and (2) energy sources that facilitate continued economic growth without destroying Earth's atmosphere. Many believe that, if humanity could just achieve these two goals, a prosperous future can be assured.

Although we believe that these two accomplishments are necessary if sustainability is to be achieved, we are skeptical that they are sufficient conditions. There are a number of reasons for our skepticism. First, we do not believe in the "technical fix," that is, the somewhat miraculous invention that magically eliminates a major social dilemma. Second, we do not expect that, even with a near-limitless energy source, it is possible to escape entropy (associated with the Laws of Thermodynamics) or avoid eventual depletion of resources and "pollution space." Third, we do not think it either feasible or possible for one billion rich people to continue living relatively luxurious lifestyles while the other six or seven or eight billion remain mired in poverty. Finally, we do believe that sustainability cannot be generalized across the planet; it must be tailored to specific times and places. That means there are no silver bullets, no miracles, only very hard work.

How, then do *we* understand "sustainability?" While we do include most of the general principles expressed above—reduced resource use with much greater efficiency; new technologies and improved old ones that can provide the services we need with greater efficiency and for longer periods without obsolescence; and a general move in toward "green" products, psychologies and practices—our notion of sustainability as a social project points toward significant changes in how each of us, as individuals, societies and nations, and how the world approach the processes of *production* and *reproduction* in ways that facilitate both meaningful lives and environmental preservation. This is a desirable objective, an ideal if you will, rather than a concrete end point, and pursuing the objective will require us to consider carefully *how* we live, what we *want* out of life, what we *need* to fulfill that life, and what changes are necessary in how we live to make it possible to live as we would like. All of this, it might be added, also ought to contribute to forms of political freedom.

Now, this might seem like a prescription for green consumption or an environmentally-friendly lifestyle, but it is not. Each of us is deeply embedded in a *culture* that shapes many, if not most, of our desires and wants, as well as in a *nature* that imposes real limits on what we must acquire in order to survive, individually and collectively. Moreover, although cultures are very fluid and change all the time, there are particular underlying principles and practices that maintain them as identifiably distinct from one another. Changing those elements is a social endeavor and not an individual one, as we shall see. Similarly, if we are to survive biologically, it is not enough to find ways to extract more and more from the ecosphere to meet our needs, wants and desires, we also must ensure that we do not destroy nature and ourselves.

Sustainability, then, can be understood as the following:

- Production, distribution, consumption and disposal of goods and services in such a way as to minimize depletion of resources, impacts of consumption and disposal of goods and services on the ecosphere, and fair distribution of goods and services among the world's people; and
- Implementing political processes of decisionmaking that facilitate people's ability and capacity to play a role in the conditions of their own lives and their communities' well-being; and
- Reliance on technology as a means towards social ends rather than as an end in itself, and recognition that not all technologies that are feasible need be developed and deployed.

Note that this definition does not rely on either the technological fix or boundless economic growth, and that it assumes the necessity of mechanisms of social debate and choice other than only the market and representative democracy. In the rest of the book, we will frequently refer to technological possibilities for achieving sustainability, but we will also point out the physical and social constraints on their deployment. And, we will make our proposals for getting to sustainability not on the basis of economic cost-benefit analysis (although this is not unimportant) but rather on the basis of both social and ecological costs, distribution and fairness.

Mapping sustainability as a social project

As the foregoing suggests, the actual mapping of sustainability as a social project is not a straightforward task. Many analysts and scholars have devised various kinds of flowcharts and network diagrams to illustrate the flows (or throughputs) going into and leaving the various parts of our societies (see the figures I-2 & 3; they are called Sankey Diagrams; see http://www.sankey-diagrams.com/tag/mfa/ for details). Of course, those parts number in the thousands, and they range in size from homes and buildings to entire

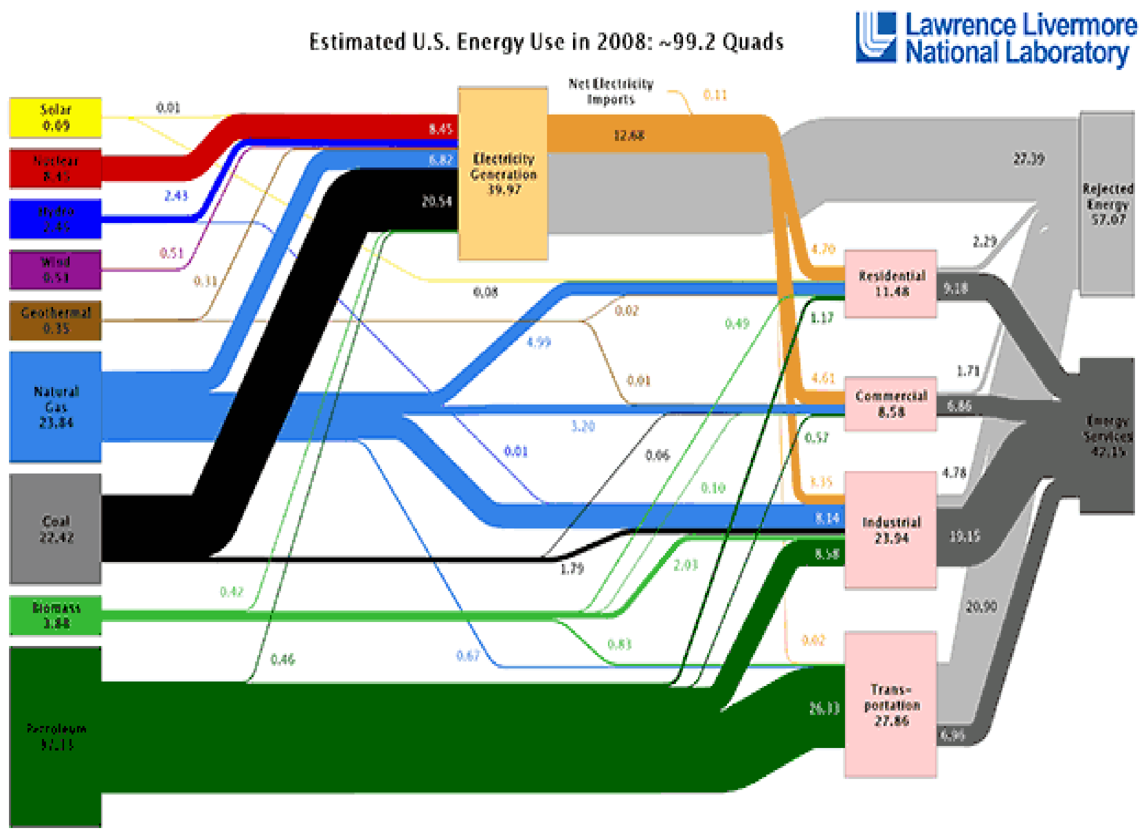


Figure I-2: Sankey Diagrams of U.S. energy flows
Source: http://www.sankey-diagrams.com/tag/mfa/

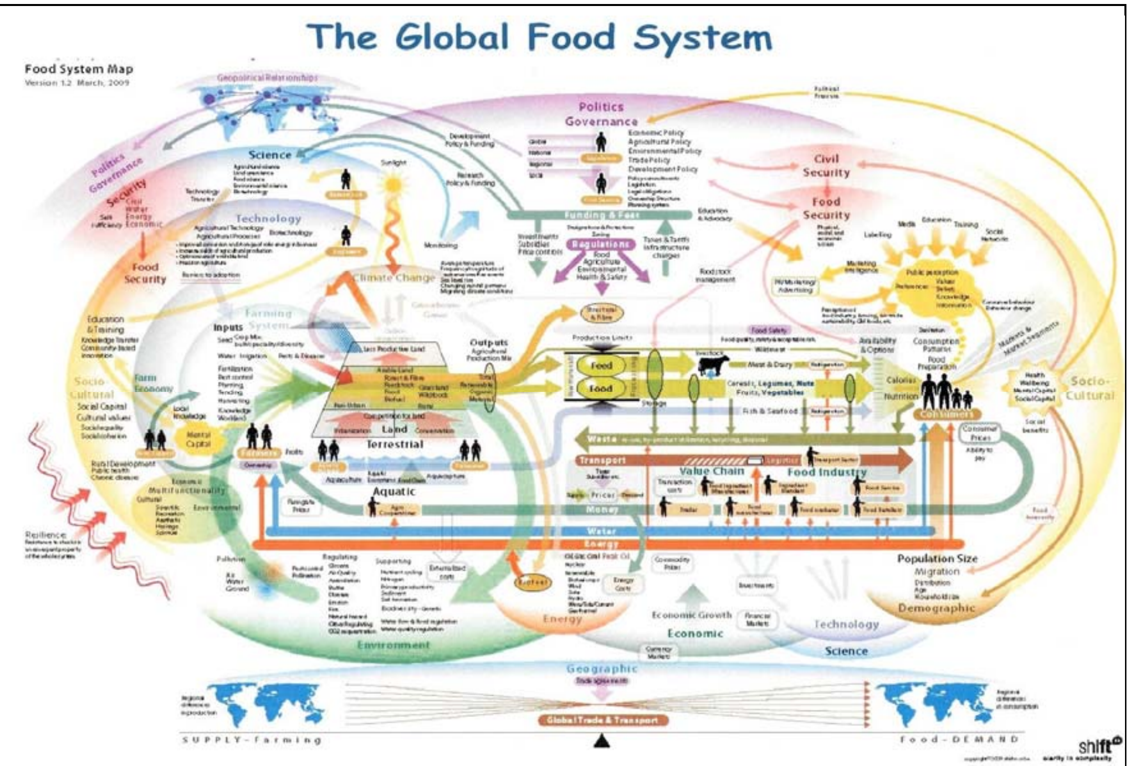
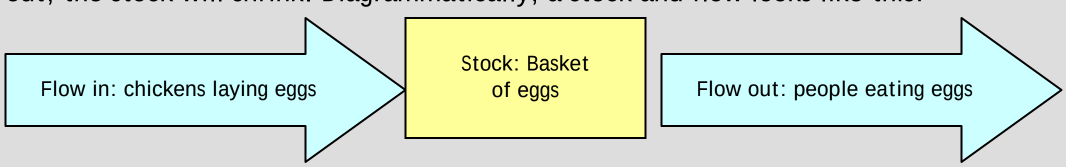


Figure I-3: Global flows of materials and foods
Source: http://foodtechconnect.files.wordpress.com/2010/07/food-system-map4.jpg

economies. Clearly, it would take lots of people collecting vast amounts of data and running them through many computers to develop a comprehensive map of *everything* that goes into societal and global production and reproduction, and *everything* that comes out. But the point of mapping is not to include *everything*; it is to provide the lay of the landscape, a picture as it were, and to get you to thinking about what is the map reveals and what it obscures.

For the purposes of this section, then, let's think of a simpler example. What goes into a building and what comes out? And how is that stuff used and for what purpose? Figures I-4 & 5 illustrate two different ways of thinking about inputs and outputs. The first figure portrays a building as an ecosystem composed of different functions and sub-functions. Each of these sub-functions can be quantified for a specific building and compared to the "best available technology," with the difference between the two showing the potential for reduction of flows through the building. But some of those sub-functions might be dispensed with entirely while others can be replaced. The second diagram is a more conventional stock-and-flow map illustrating building operation. What is notable about both is that neither shows inputs such as food, fiber, furniture or (human) physiology, among other things.

Box I-2. Stocks & Flows: A "stock" is an accumulation of something—a material, a population, a gas, money—and a "flow" in the quantity of that something that moves into and out of a stock. If the flow in is greater than the flow out, the stock will grow; if the flow in is less than the flow out, the stock will shrink. Diagrammatically, a stock and flow looks like this:



For more information, see: http://www.seed.slb.com/subcontent.aspx?id=4014

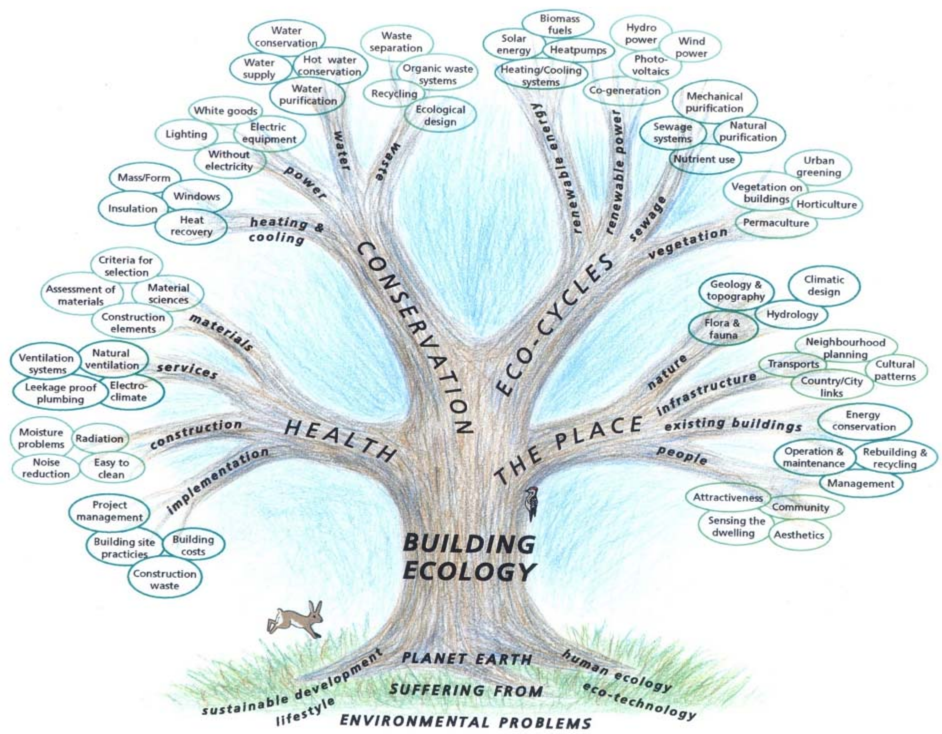


Fig. I-3: The house as an ecosystem

Source: http://www.blockark.se/en/images/Tree_Light.jpg

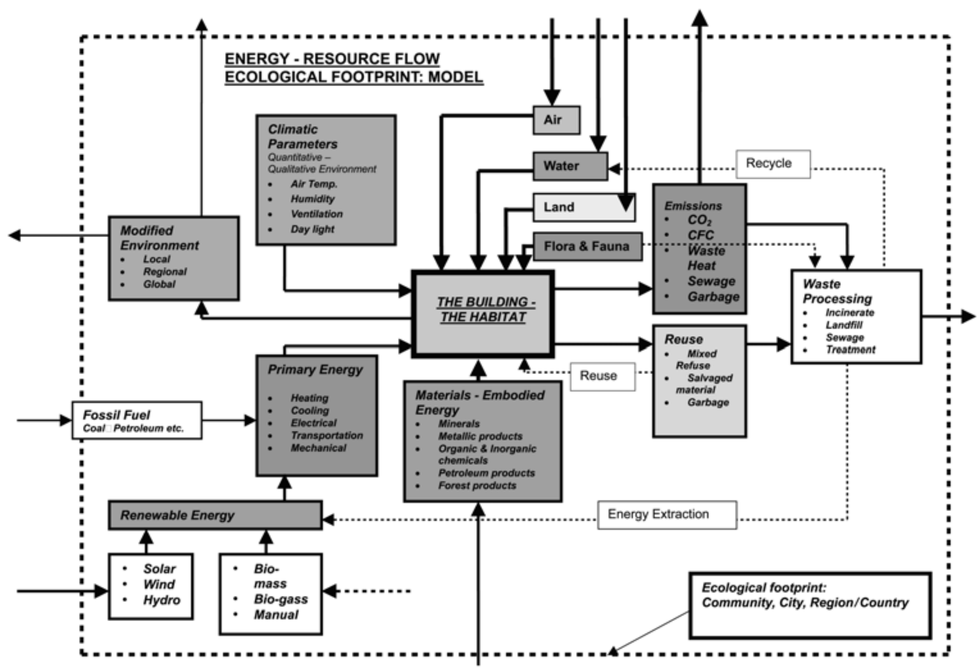


Fig. I-5: The house as stocks and flows

Source: http://www.emeraldinsight.com/content_images/fig/0830130409001.png

But we are not yet finished with this mapping exercise. A building starts with a conceptualization, perhaps imagined by the future owner or builder, perhaps designed by architects and engineers. The very form of that building might be dictated by function (for example, search for on-line photos of old gas stations; they differ greatly in appearance but most share a set of similar functional features) or by desire (search on-line for "office buildings," whose forms often reflect the whims of architects and developers). In either case, *design* must take into account what materials will be used for construction and finishing, what flows of materials and goods through the building will be necessary for operations, services and maintenance, and even how people will interact with the building and each other once they are ensconced in it (this is always a very tricky proposition; occupants often do not behave as anticipated). The point here is to think very carefully about the relationship between the building's "ecosystem" and its "social system." Both must be sustainable if the overall building is to be described as such. That means keeping in mind not only what goes into the building but how the building "fits" into the beliefs and practices of a society and community, how people "fill" the building in accordance with their needs and desires, and where stuff goes when it leaves the premises (out the door to where? into the sewer to where?).

As a concrete example, consider your home. Assume that you live in a rented apartment, in a low-rise complex of fifty such units mostly occupied by students. The building is located one-half mile from the center of your city of 50,000. Such structures are ubiquitous across the United States, especially in college towns; they are usually constructed so as to minimize the costs of construction, operation and maintenance, and to maximize returns from rents (students, not being able to pay top dollar, will not demand luxury housing). Although designers and developers expect that some residents will own cars, many will rely on buses and bicycles to get around. Handy access to the town center and its shops can reduce auto use. Renters, as a rule, do not have to pay for their energy or water use—although this varies from one building to the next—and are not especially frugal in this respect. Students tend not to furnish their apartments with costly furniture, which is more easily abandoned or thrown out than moved. There are often high throughputs of "stuff" through the units.

In a broad sense, then, the apartment complex and your home fill a functional need in college towns—off-campus housing—based on a more-or-less standard building model that varies only in details from one structure to the next. This reflects the general social sense that students tend not to take very good care of their living spaces and that solid, high-quality and long-lasting construction makes little economic sense. Students are also transient and, it is thought, don't care that much about ambience or durability; if they don't like where they are living, they can always move. But students do bring a lot of money into the community, so services should be provided without investing too much in them.

We can think of your home in terms of stocks and flows, but with a twist: stuff goes in, it stays there for varying amounts of time, and then it flows out.

What goes in and what comes out is not determined, however, even as specific choices regarding flows into your space are strongly dependent on various kinds of norms and normative practices having to do with building, maintenance, operation and use, and furnishings. A considerable quantity of materials goes into preparing the building site and building an apartment complex. These materials require energy, water and other inputs in order to be made suitable for building; such costs are not, however, absolutely fixed, since there are alternative materials as well as the possibility of recycling from buildings that have been "deconstructed." Specific choices of materials (e.g., wood vs. stucco or brick) may be normative or required by building codes, and they will almost certainly be influenced by both material and construction costs. These embedded or "sunk" costs must be taken into account in mapping sustainability.

A second element of the mapping exercise involves the "operation and maintenance" (O&M) of your home. O&M includes, on the one hand, the resources that flow into the building—gas, electricity, water, food, fiber, furniture, things for replacements and repairs—and, on the other hand, in what way and how intensively they are used and how particular practices and choices are influenced by social norms, peer pressure and habit. For example, one person might do a great deal of cooking, entertaining and washing up while another might eat out most of the time. The former could put a premium on solid, attractive furnishings while the latter might have a mattress, a lamp, a couple of wooden boxes on the floor and a calendar on the wall. One person might clean house regularly and rigorously, the other not at all. One apartment might have a single resident, another four or more. Thus, there are both general and specific patterns of behavior, the former social and the latter individual. It is important to distinguish between these two "levels" in mapping sustainability and to recognize how each is determined and might be changed.

Finally, where does everything go after it is consumed or you have moved out? Remember that outflows include noxious gases, heat and sewage as well as garbage, old furniture, and other wastes, all of which end up in the "environment." And nothing these days lasts forever; sooner or later things break or break down, and repair often costs more than purchasing a new item. Where do such things (e.g., computers and cellphones) go after they die? Is there something else that can be done with them besides throwing them into the trash from whence they will be shipped to rapidly-filling landfills? The energy, resources and labor embedded in these objects can be considerable, and a once-through cycle adds little to overall sustainability. As an exercise, we encourage you to map sustainability in your home, as described in Box I-3.

Thinking through sustainability engineering and design

A critical element of any sustainability strategy or plan has to do with *design*. In using this term, we mean not only how something looks or operates but also how it *fits* into the sociosphere and how it both *enables* and *facilitates* sustainable practices. Many things are poorly-designed for everyday use and some actually exacerbate the very problems they are intended to address. This is not necessarily because the designers and manufacturers were incompetent

Box I-3. Mapping sustainability in your household: As figures I-4 and I-5 suggest, the house is a complex system, which can me mapped in various ways. For our purposes, it is probably easiest to think of it in terms of stocks and flows. The structure is a stock of various materials, with specific properties and "containing" quantities of embedded energy (that is, energy used in extraction, processing, transportation and installation). Once construction is completed, these stocks remain fairly constant over the lifetime of the building—although there may be additions, renovations and other changes, which you do not need to consider here. At the same time, there are stocks in the household that vary over time, with flows in and out. For example, even if your refrigerator is empty, there is probably some food in the cabinets. When you bring food home, that adds to the stock, and when you eat it and throw out what's left, that diminishes the stock, with an outflow of various forms of waste. The same is true of water, electricity, natural gas, air, heat, furniture, clothing, books, CDs, and even people (a person at rest emits the heat equivalent of roughly a 75-100 watt incandescent light bulb).

Your task in this exercise is to draw a diagram of household stocks and flows and, for a typical day, estimate the energy content of those stocks and flows. This means that you will need either to find appropriate data or to estimate the energy content of the various components of the building "envelope," the quantities of energy that flow into the building, as electricity, natural gas, food, people and other materials, and the quantity that leaves the building, in the form of heat transfer through the envelope (heat produced by appliances and people) and various forms of waste and garbage.

It is likely that you will not be able to come up with more than an "order of magnitude" estimate, for example, a daily flow through the household on the order of 200 kilowatt-hours (transformed into electricity equivalents for our purposes). You might be off either way by 100 or 200%, but you know the number is much greater than 20 kWh and much less than 2,000 kWh.

Consider also the following questions:

1. How much warmer is your house when it is occupied on a daily basis than when the people living there go away for a week?

2. Which energy uses are "subsistence" and which are "luxury?" Are there things you could do without, or ways to use less energy doing them?

designers and manufacturers expect or intend them to. Sometimes, people's intuitive interactions with devices are counter to the designers' intentions; at other times, what designers regard as straightforward instructions or use are unintelligible to users (computer manuals are a good example in this regard). In this sense, then, design is not merely about how something is built, how it looks and how it is intended to be operated. Design also involves how people will *use* a thing (not how they are "supposed" to use it). And, if a thing or process designed to be sustainable is used routinely in an unsustainable fashion due to "incorrect" use, then the problem is with the design and not the users.

One example of this is the paradoxical effect on driving patterns of fuel-efficient automobiles. We might expect that, in replacing a gas guzzler with a fuel sipper, the average driver would see a significant drop in her gas consumption, thereby saving money and reducing emissions. Broad experience indicates, however, that people may well begin to drive more, and go on longer trips, because the relative cost of fuel has dropped (that is, it costs less to travel greater distances). Indeed, this is what happened during the late 1970s, following that decade's "energy crisis" and a widespread shift from large American cars to smaller Japanese and European ones. Later in this book, we will explore how this particular problem can be dealt with. To repeat the point: sustainability *design* must take into account both user and using practices, and not only appearance and intended operation.

One difficulty with taking users into account is that many designs and processes have a long history and people do not want to learn new ways of doing things with which they are familiar. A particular design may be the result of various kinds of engineering limits when a device was first developed or it may simply have become a "custom," one that could be changed but is not for fear that users will shy away. For example, when typewriters were invented, the typebars (the arms with letters at their ends) jammed if the keys were pressed too rapidly while typing. Because there was no other way, at the time, to construct a typewriter, the solution devised was to reduce typing speeds; as a result, the "QWERTY" keyboard became the standard. Today, computers have no typebars to jam and more efficient keyboard designs would permit faster typing (or so we are told). But QWERTY has been the American standard for close to 150 years, and few people are willing to purchase or install other keyboard layouts, or spend the time learning a new one. (This phenomenon is called "path dependency"—once you sent out on a particular path, changing it later becomes progressively more costly and difficult, so the path remains the same.)

In the case of electricity, as wires were strung around cities, it became evident that "economies of scale" pointed to centralized generating plants. And, there was no point in putting up duplicate distribution systems to buildings (although the same was not initially true of telephones; in some places, phone companies competed and people had a different phone for each company). As a result, electric, gas and water utilities (and later phone companies) were granted regulated regional service monopolies, permitted to charge approved rates and allowed to earn a fixed profit on sales. This became the standard across the industry, although some customers, such as hospitals and factories, maintained in-house generators for power outages.

With the arrival of rooftop solar photovoltaic (PV) arrays, however, decentralized power generation has become more practical (if not less costly). Electric utilities now find themselves in something of a bind. If they encourage customers to install PV systems, they risk losing electricity sales and might even be required to purchase any excess electricity generated by the PV arrays at a high cost (as was once the case in California). If utilities finance or lease the systems to users, they can avoid building new power plants but might generate lower revenues and earn less profit. Someone will have to maintain the PV arrays and make sure they are working properly, and that costs money. From the utilities' point of view, it makes much more sense to build vast solar PV arrays far from points of use and provide the electricity via the existing transmission and distribution systems. Many building owners might prefer this, too, since it relieves them of any responsibility for a local PV system.

These two examples—and there are many others—point to the importance of considering the sociosphere and its *history* where sustainability engineering and design are concerned. History matters in at least two ways. First, landscapes have been shaped by human action over time and remain relatively fixed; we do not, willy-nilly, tear up or down those structures, built long ago, that still serve a purpose. New projects and devices must be designed and deployed taking into account what already exists and being aware of how that existence can affect the use and success of the design and operation. In many instances, moreover, the particular shape of the human landscape sets patterns of behavior and practice that are not easily changed, due to both cost and habit. It makes considerable sense to rehabilitate old, abandoned factories to new purposes—the energy embedded in such structures is considerable—but it might be doubted that new shopping malls created out of such buildings will make a substantial contribution to sustainability.

The second way in which history matters is in *habitus*. This is a term coined by the late French sociologist, Pierre Bourdieu; it does not mean "habit," which is how we might translate it (such words are called *faux amis*—"false friends"—because they appear the same as an English word but have a different meaning). Rather, *habitus* is the internalized and repeated *practices* that people learn while growing up and living and working in particular environments, and which everyone engages in and believes to be natural and normal behavior. For example, the custom of looking straight ahead and making no eye contact or small talk in elevators is a form of *habitus*. There is nothing intrinsically or socially problematic with speaking to a stranger in such a situation; it is simply *not done* (which is why advertisements and songs make such a big deal about love arising from such random contact). Similarly, societies and people may act in ways that counter the goals of sustainability because that is how things have always been done. Anyone who begins to behave differently is likely, at first, to be socially-marginalized or even deemed a "kook" (although, subsequently, they may be lauded as visionaries).

Deeply-internalized *habitus* can be changed, but such change does not come quickly or easily. Fifty years ago, very few people thought about, or were even aware of, what we today call the "environment." Nature was something to be conquered and shaped to human purposes, and there was an almost boundless faith in the potential for science to solve all problems. Schools taught geography—where countries were located, their topography, what things they produced and exported, how their people dressed and danced—but said little or nothing about their environments. Today, it is geography that is not taught—Americans, in particular, are famed for their geographic innocence—whereas instruction about the environment is ubiquitous in schools, songs and sales. Of course, there are still many people who believe that nature is inexhaustible and that the "environment" is only of concern to liberals and leftists (a notorious bumper sticker reads "Earth First! We'll mine the other planets later!) But in the United States and Europe, at least, people have become very conscious of the environment and behave in ways calculated to protect it. This is not only the result of individual belief and choice, it is also a consequence of longer-term changes in *habitus*.

Another factor that makes such changes difficult is outright resistance by organized economic and social interests and groups. Those who have extensive investments, experience and commitment to particular forms of *habitus* will tend to oppose intentionally-directed changes, unless they think it is to their benefit or well-being (those with high-quality health insurance are often opposed to comprehensive health reform in the United States). The reasons for this are not difficult to understand. In a capitalist economy, people, companies and institutions invest their capital, skills and knowledge in specific ways, and they expect to realize some kind of return or profit as a result. Change may require additional costs, and major change can abolish or wipe out sunk investments. Few people are willing to lose their money in the service of a cause as abstract as sustainability—this would be "privatizing losses and socializing benefits"—and so they will lobby to prevent new policies and practices, even if everyone will be better off in the long run.

An excellent example of this phenomenon can be seen with respect to global climate change (GCC). The vast majority of scientists who are knowledgeable about GCC agree that it will result in large ecological and social costs whose distribution around the world remains highly uncertain. Economists have suggested that the cost of amelioration and adaptation over the next 50 years could be on the order of trillions of dollars per year, with much of that to be borne by industrialized countries. Who specifically will benefit from such expenditures is not certain, however, and corporate interests are especially concerned that they will have to pay out more than they will get back. Their current investments may turn into losing propositions and, over a 50 year period, benefits realized in the future have much less value than costs expended today. So, those parties have a vested stake in opposing action on climate change. To be sure, there are others who see opportunities from the innovation and change that will be required, but there is no guarantee that they will reap profits from "going green."

Opposition to action on GCC comes in three forms. First, the science is attacked. Second, those who accept the scientists' warnings as valid are ridiculed. Third, people are warned that their lifestyles will be irrevocably altered and they will lose their freedoms. Both "lifestyle" and "freedom" should be understood here as forms of *habitus*, of normalized behavior that takes place within a larger social arena. One can change one's own behaviors and even those in one's family or household; it is much more difficult to change a society's *habitus*, especially if the sociosphere is configured in a way that makes such change difficult.

To return to an example discussed earlier, consider automobility. Cars represent a significant source of greenhouse gases; individuals can choose to buy and drive cars that are more fuel-efficient and lower-emission, or they can switch to trains, bikes and buses. But how could all of society be induced to do similarly? For that matter, what would it take to get Americans out of their cars and into other, more efficient forms of transit and transportation? Since early in the 20^{th} century, American society has been built around mobility and the car as something close to a "birthright," and our cities, suburbs, highways and transportation systems reflect this (must every building front on a street?). Moreover, vast industries worldwide are heavily invested in American automobility: oil producers, auto manufacturers, tire companies, gas stations and repair shops, advertising, the U.S. Department of Transportation, state departments of motor vehicles and highway patrols, drive-ins of various types, and on and on. Unless one lives in the center of a city, such as Manhattan, Chicago or San Francisco, it is almost impossible to live without automobility (in some sprawling cities, such as Houston, Oklahoma City and Phoenix, it is even impossible to live in the center without a car). Automobility constitutes a vast material-ideological-practical assemblage that is habitual and into which people and institutions are substantially locked. Resistance seems futile and escape impossible (one of the chapters in this book examines this issue in much greater detail).

The upshot is that sustainability *engineering* (and not just design) must encompass a great deal more than just the technical specifications of things and processes; it must also consider *social* engineering as an integral part of moving toward sustainability. As noted earlier, "social engineering" has a, perhaps unjustified, negative connotation; it is widely understood as involving efforts by state and government to make people change their behaviors, against their will, through information, education, admonition, regulation and punishment. But social engineering happens all the time, via advertising, in schools and churches, in the family and household, and through peer pressure. Here, we use the term not to mean state enforcement of mandatory change but, rather, taking into account the ways in which *habitus* can be transformed over time, though the engineering of both the "hardware" that people use in everyday practice and the "software" that explains how and why those practices are performed everyday.

Toward technological and social literacy

As the authors of this handbook have searched for programs, projects, pedagogy and publications on sustainability, we have found, for the most part, the same dichotomy described by C.P. Snow, a British scientist and novelist, in his 1959 Rede Lecture. Snow addressed what he called the divide between the "two cultures" of science and the humanities (here we could substitute or add "social sciences"). He observed

> A good many times I have been present at gatherings of people who, by the standards of the traditional culture, are thought highly educated and who have with considerable gusto been expressing their incredulity at the illiteracy of scientists. Once or twice I have been provoked and have asked the company how many of them could describe the Second Law of Thermodynamics. The response was cold: it was also negative. Yet I was asking something which is the scientific equivalent of: *Have you read a work of Shakespeare's?*

We believe that a basic requirement of working in, on and toward sustainability is basic literacy in both "technology" (including the natural sciences) and the "social sciences" (politics, sociology, political ecology, anthropology, psychology—and we could add the humanities, too, including history). We do not expect the social scientist to become fully conversant in thermodynamic equations, just as we do not expect the engineer or natural scientist to write learned treatises in sociology or politics. We do hope, however, that these two cultures can communicate and work with each other and, in doing so, generate a new interdiscipline that we call "sustainability science, engineering and social studies."

This book has been written toward that end. Each chapter is organized around a "problematic," a set of problems that has been identified as critical in working toward sustainability, and problem-solving. By taking this approach, we can offer both the quantitative and technical features of the problematic and the sociological and policy aspects that have led to the problematic and that might be able to address it. Thus, for example, we have not devoted single chapters to energy or water or cars or buildings or food; instead, these appear throughout various chapters focused on general problematics. Thus, for example, in different places in the book, we treat energy as a social project, as a commodity, as a substance or process, as integral to biological life, and as embedded in human artifacts, among other topics. Where these topics appear, we also address scientific and technical matters, for example, the Laws of Thermodynamics and the concept of entropy, the physics of food growth and consumption, how much stuff becomes waste and the life cycle analysis illustrating where waste might be reduced or eliminated, how buildings and people in them use and waste energy, and so on. Some of these matters, whether technical, scientific or sociological, are addressed in the main text while others are in boxes and tables.

Finally, at the end of each chapter, we pose several "thought exercises" (in German, *gedankenexperiments*). These are not "problem sets" as often assigned in science and engineering classes, nor are they "essay questions" as sometimes required of students in the social sciences. Instead, each exercise poses a scenario and questions that draw on both types of literacy. Quantities must be found or calculated, and technical decisions made, but social factors and assumptions are also important, as is "problem bounding." These exercises are, obviously, not meant as comprehensive studies of problematics; rather, they are designed for learning about how to conceptualize and address problems, to which there are always multiple "solutions." Box I-4 offers an example of such a problematic.

Box I-4: Subsistence and Luxury Consumption: Energy is important for the services it can provide, which means that it is as important to consider how it is being used as in what form it is supplied. It is possible, as a thought-experiment, to classify energy use into two categories: subsistence and non-subsistence. The first covers those basic needs people require for their well-being (food, water, housing, clothing, work, etc.); the second, those things that are not absolutely essential but which provide for growing degrees of comfort (e.g., air conditioning, sushi, cars, etc.). How much of the United States' energy consumption falls into the first category, and how much into the second? You will need to set boundaries to this problematic and to make clear your assumptions, because there are not enough data available to provide a precise answer. Nonetheless, this can tell us something about the distribution of energy uses and where reductions might be made. Please do the following:

Step 1: Look for appropriate data on the internet, that is, information about energy *end-uses* and *sources*. It is also useful to look for comparative data from a few other Industrialized countries; this allows you to see how much energy is produced and consumed in places with similar living standards.

Step 2: Decide what constitutes "essential" and "non-essential" end use. This requires your judgment about "how much is enough?" Since most data are not disaggregated in this way, you will also have to decide what fraction of energy use for a particular sector falls into each category. Be sure to explain your reasoning.

Step 3: Might some end-uses be replaced by other services (e.g., bike for car)? Might some energy sources be replaced by more efficient ones (e.g., natural gas for electricity for cooking and heating water)?

Step 4: Prepare a short report detailing your findings. Be sure to make your assumptions and calculations clear, and to document the sources of your data and any other information you may have used.

~~What is in the rest of this book?~~

~~As we noted above, because this handbook is structured around problematics rather than concepts, objects and policies, some topics appear in multiple chapters. The Index provides a guide to where in the book, for example, various energy sources are addressed. If you wish to read about topics, rather than problematics, please consult the Index.~~

~~The first part of the book addresses sustainability in the ecosphere and focuses more on problems pertaining to the "natural world," while the second~~