Chapter Five    Section One

Account Principles for Economic Policy

Ecological Accounting

Ecological accounting must advance beyond environmental and economic accounting. It needs to be constructed so as to catch those parts of information flow and storage that can be affected by community organization and social policy.

Effective planning cannot avoid measurement, because democratic planning must be even-handed. Needs must be estimated and matched against resources, and fair divisions made.

Timing can be crucial. Thus, planning requires quantitative accounting that deals with as many flows as there are specific needs. Managers have working accounts to keep the life processes of enterprises and public services going on a day-to-day basis, assuring that deliveries are on time, and stocks do not overflow.

Accounting for "populations interacting with each other and their environment" has not yet been conveniently organized, so we have to look around for meaningful contributions.

The discussion that follows starts from the classical tradition of accounting for:
- space
- time
- energy
- matter
- economic value

to provide a perspective for the recently revealed time budget measures, transaction counts, information stocks and flows, and the latest, which are human attention and human happiness.
Communities, however, often wish to choose their own indicators of a path to collective well-being based upon local experience, which is a bottom-up instead of universal approach. How planners representing the community’s do desire guide planning, management, and design? They look for paths that fit the data. After all, accounts are a means of optimization, but are the aim steady state, welfare, or happiness? Achievement of the goal needs measurement also.

Planning looks beyond the next budget at the long-term prospects. It uses quantitative measures, but also adds informed judgments wherever hard data are not available. Ecological planning, it has already been argued, takes more factors into account than the present economic and social planning.

That is especially evident in the comprehensive checklist of input and output categories in Figure 2-2 but that diagram cannot reveal the crucial detail.

Simplification for strategizing is a necessity for practical planning and management. Both are conscious of the substitutability of a part of one input for another, so they try to cluster and aggregate to a few tens of the thousands of categories of commodities and services for which accounts should be kept. A set of accounts should have a logical basis that makes it possible to connect with fundamentals discovered by scientific analysis. Planners and managers especially want to have relatively unambiguous ways of classifying the 2 percent or so new items appearing on the scene annually.

In the search for ecological fundamentals, each body of philosopher-investigators chose the basic requirements for sustaining a living system.

Thus the bio-ecologists focused upon nutrition, reproduction, location, and corresponding transactional behavior (ethnology) was related to these dimensions.

The human ecologists added households and deviations from the norm in them, such as illness, accidents, delinquency, etc.

Very recently they have added energy, the forms of which had conveniently been reduced to a set of thermodynamic accounts by scientists and engineers.
Political scientists added voters, real and potential. Karl Marx chose labor, while other economists included land (as a shorthand denotation for all natural resources, but soil was the most important at the time) and capital, which they converted to money equivalents with the aid of market prices and convenient approximations.

Boulding's triad
- energy
- information
- materials
makes use of all of these special cases and refers to the most precise scientific measurable. The utility of these three categories for the kind of accounting that measures deviations from sustainability -
- growth
- maturation
- imbalance
will be illustrated.

Criticisms of the existing accounts used by economists will not be undertaken here in detail, because they are best done by new groups often classified as “evolutionary economists.” Their books are beginning to appear, and they have started a journal that is addressed to reform, primarily through the removal of paradoxes, double counting, and undercounting.

A new system of ecological accounts must take these suggestions into consideration. It is also possible to appraise the current situation that these indicators reveal, including factors essential for long-term stabilization, which were previously handled as a matter of good judgment, if at all.
Chapter 5 Section Two

Evolution of Accounts in Wealth and Energy

Origins of Accounts: Wealth and Energy

History offers the simplest way of understanding the present state of accounting.

The first true accounts, which measured flows in and out of a treasury and a warehouse, are ascribed to the Venetians as a private, confidential effort to keep control of commerce at their trading posts, perhaps around the twelfth century. With such accounts they tried to measure the profit from enterprise. They set up a counting house for gold, silver, base currencies, obligations to pay, and certifications of cargo, as well as stocks in storehouses. They were able to aggregate the values of what was owned into a measure of wealth attributed to the respective merchant households.

For many centuries this evolving ability to measure commercial values ever more precisely kept the Venetians ahead of their competition. Their techniques were imitated and widely diffused. They proved that double-entry accounting pays.

On the other side of the world, where commerce had reached the same stage of intricacy only a little bit later, the Japanese merchants of Edo and Osaka worked out their own version of accounting. It is one of the paradoxes of world history that the European version became a foundation of the livelihood of an urban community, the bourgeois stratum, whereas the Japanese and their Chinese trading partners eventually were ordered by their emperors to break off dangerous contact with the outside, thus atrophying the advance.

Free trading communities had a more open culture, which made it easy for natural science to progress and diffuse among the residents.

Navigation instruments used to measure distance, whether at sea or on land, were combined later with the chronometer, which measured time.
Astrology, which was shared with the East, gave way to the more solid base of astronomy, which bolstered the measurement of space. Another kind of space-time accounting arose which permitted the founding of transoceanic empires and transcended the efforts of the Chinese vanguard. Around 1500 A. D., when the two systems collided on the fringes of the Indian Ocean, the space technology of the Mediterranean was clearly more effective.

Out of this trading experience with stocks and flows came the recognition that some properties were conserved, which is, maintained at constant levels even as other properties changed.

Simple addition and subtraction were the only calculations needed to show what was in the granary. Weight was conserved, and the same was true of bullion. Conservation laws are powerful wherever they are discovered.

The principle of invariance -- that quantities are conserved both in space and in time -- is the basis for energy accounting: What energy came into a closed system eventually came out. If it did not, it would be found to reside inside as a stock on hand, often in the form of a changed state of matter (i. e., ice and vapor instead of water).

Each change involved a constant quantity per unit mass of a given substance. Each pure material gave reproducible results everywhere on Earth.

Key inventions set the stage for energy accounts. The thermometer, to measure the degree of heat, and the calorimeter, to measure quantity, made heat quantification feasible. Until then, energy had been a highly elusive phenomenon, as compared to space and time. Sometimes it can be felt, and sometimes not, so psychological judgments are ineffectual.

It took almost the whole of the nineteenth century to learn how to account for:

- heat and heat flow
- mechanical energy
- rotational energy
- electric power
- sound
- energy from electromagnetic vibrations
The conversion constants for transforming one form of energy into another were calculated from experiments with ever-improving precision. Economists, given their commitment to marginal analysis, which was borrowed from the mathematical physics of the day, should have become involved in energy accounting. However, their central interest in pricing through the market prevented this from coming about. We are indebted to Juan Martinez-Alier (1990) for bringing to light the work of the intellectual scientists and engineers who circulated on the fringes of the political economy circles in Vienna, the salons of Paris, the lecture halls of Berlin, and the libraries of London.

They interpreted the sociopolitical and economic meanings of the discovery of the laws of thermodynamics and the prospects for a sustainable society only a decade or two after their announcement, only to be roundly criticized by the economic lions of the period--Karl Marx, Max Weber, and L. Walras, in particular--for what are now known to be wrong reasons. After that, the energy message of the nineteenth-century economists was promptly forgotten until the "energy crisis" of the 1970s generated attention, and Nicolas Georgescu-Roegen (1976) wrote about energy and the economy.

Wasteful mis-pricing of fuel, which deflects attention from its anticipated scarcity even before the life cycle of the present energy-using infrastructure has run out, was attributed to market imperfections and erroneous regulation, not to bad science and inadequate accounts within the economics profession.
Chapter 5 Section Three

Laws for Conservation in Energy

Laws of Conservation: Mass and Energy, Work and Entropy

The first law of thermodynamics states that energy is conserved.

It defined energy so that it should not be lost when it changes from one form to another, just as the Venetians had defined wealth so they could measure and keep track of it. This was the basis for energy accounting: What went into the system ultimately came out. If it did not reappear, it was found to reside in the "exchequer" as a changed state of matter. All sharp changes in matter, whether from solid to liquid or liquid to gas, involved a constant quantity of energy per unit mass of a given substance. Each pure material gave reproducible results everywhere on Earth. Early in the nineteenth century the accounts became quite elegant, so long as the substances containing the energy did not interact with each other.

When materials react, as in combustion and corrosion, they almost always give off heat, but sometimes a technology is created in order to produce something else. Thus scientists induced a particular kind of corrosion to generate electricity from batteries. Shortly thereafter they found that moving a wire through a magnetic field could produce it. A broad set of experiments were undertaken from which tables have been constructed that report energy content, or "fuel value," of pure substances.

These values were reported for a temperature of twenty degrees Celsius, and a barometer reading of 760 millimeters of mercury (which is sea level average), so that minor adjustments could be made for changes in altitude and in temperature of the surroundings.

Scientists have agreed upon names for the respective pure substances. With the advent of atomic theory they developed increasingly complex images of how the atoms in each substance are connected and arranged.

In that imaging system, heat is defined as the jostling of the atoms. At high temperatures the movements become so agitated that the weak connections
between molecules break down and the atoms reform, as in the case of melting and boiling.

At even higher temperatures tightly bound molecules are ripped apart by the jostling in their vicinity. When the conditions are very hot, we see flames, and new molecules are being formed.

Then, in the case of combustion and other kinds of reactions, we arrive at the desired expression of accounting, which takes the form of the equation

\[ AB + CD \rightarrow AD + CB + \text{heat} \]

Example: \[ 3 \, \text{O}_2 + 2 \, \text{CH}_4 \rightarrow 2 \, \text{O}_2\text{-O} + 4 \, \text{H}_2\text{O} + 13.2 \text{ kilocalories (per g.CH}_4) \]

\[ \text{Oxygen + natural gas} \rightarrow \text{carbon dioxide + water + heat} \]

It is noteworthy that in some circumstances, part of that energy can escape the immediate vicinity in the form of light from a flame. However, heat is obtained wherever that light is absorbed, and when it is included the equation holds very nicely. The experimental values of "heat content" (enthalpy) of pure substances have been incorporated into a database of invariant thermal properties of pure chemicals.

In a completely closed space that does not allow materials or energy to escape, the equation can be reversed, although in quite a few instances it is excruciatingly slow.

A catalyst can be introduced to speed up the absorption of heat and the backward reaction. It interacts with compounds on both sides of the equation and brings about a thermal equilibrium. Incredibly, this particular backward reaction can be achieved in the open through the metabolisms of organisms.

Plants using energy from the sun and carbon dioxide from the environment can cooperate with methane-forming bacteria. These organisms play the role of catalyst, and the energy accounts apply just as well. Demonstrating the universality of energy accounts was one of the great achievements of
scientists in the nineteenth century. The first law of Thermodynamics says: Energy is conserved. It cannot be destroyed.

At the beginning of the twentieth century, with the discovery of nuclear radiation from the auto-destruction of bits of matter, the accounting encountered some troublesome exceptions.

Clever laboratory studies by the Curies and others demonstrated that a few pure substances produced extra energy at a declining rate over time while resting in a container. They also accumulated traces of identifiable impurities that had simultaneously accumulated.

Einstein provided the principle for converting the fractional mass loss into energy, and later it was shown that these nuclear reactions were responsible for the major part of the energy produced by the sun and stars.

So the exceptions to energy accounting in thermodynamics led to a new system of accounting for mass; its tables were assembled from the 1940s to the 1960s. With these interlocking accounts one could deal with the whole universe.

The conservation of energy principle was restored by combining it with the conservation of mass.

Then, a few highly refined experiments turned up some very small shortages.

A new kind of particle of very tiny mass was posited to make up the difference. In the 1930s the existence of the neutrino (an elementary particle without mass created as a result of particle decay) was demonstrated, but as the precision of the experiments improved a gap remained.

In the 1990s, the showers of neutrinos from the sun appear to be only one-third or less than the amount forecast by the energy/mass accounts. The missing neutrinos have major implications for understanding the life cycle of the sun, but have no noticeable effect on ecosystems on Earth for the futures foreseeable by planners.
This brief recapitulation of the status of conservation laws at the end of the twentieth century illustrates the utility of the two basic conservation laws, those for energy and matter. They contribute predictability for consequences of action and of environmental change for the very long run. Other eco-accounts used for revealing the future of cities, such as information, are more open-ended and therefore yield much more unpredictability.

Personal information tends to be forgotten; although information available within cities does not normally decline, when it does the effects upon the city are grave (Meier 1962).

The second law of thermodynamics states that only a portion of every energy resource can be converted to doing useful work, and the share is temperature-dependent.

The term useful work means such community activities as transport, both passenger and freight, but also including:

- pumping fluids
- generation and distribution of electric power
- production and recycling of metals, plastics, and other materials (and, their formation into artifacts)
- production of fertilizers and chemicals for enhancing food yield

The second law of thermodynamics also makes the point that a warm body of water, which possesses a large amount of heat energy, has only a minor fraction of its energy available for work, but superheated steam has a major share that can be used. A database called entropy tables provides the basis for computing what part of each form of energy can be converted to work. Tables for various fuels arrived around the beginning of the twentieth century. A designer can use these tables to calculate how much of each fuel will be needed to accomplish specific kinds of physical work with off-the-shelf technology.

Beginning in the 1930s, scientists became interested in conserving fuels possessing a high capacity per unit weight for work. This concern stemmed from a common observation that the growth in demand for electric power had previously been closely associated with increases in welfare and quality
of life. The amount of electricity generated in Western societies had doubled every decade in this century and seemed likely to continue to do so, while in most developing countries the demand tripled every decade, starting from a very low level.

When would the world run out of fuel?

Demand for electricity has almost always been ahead of the generating capacity. However, since 1960 several factors have intervened to change the relative priorities for the use of fossil fuels and their relationships to solar-derived fuels (see Box 5-1).

Box 5-1

Alternative Energy Sources beyond 2010


In the 1960s, only a thin stratum of highly select, public-oriented thinkers recognized that consumer sovereignty for energy-rich goods and services was inefficient for maintaining a conserved stock of energy. When scarcities occurred, awareness diffused to decision makers in the private sector with unusual rapidity.

Electric power and gas distribution utilities, automobile engine manufacturers, and home builders all found it important to extract more and better service from each unit of energy expended. Households and small businesses have followed.

The resulting adjustments in consumption have reduced the demand for power to about half of the projected amounts, and they can drop much further. All this has occurred without any noticeable reduction in the quantity and quality of services provided (Levine et al. 1995).

The threat of global warming from the 1970s onward, attributed to accumulating amounts of carbon dioxide and methane in the
upper atmosphere since the rise of industrialization, has shifted attention away from the combustion of coal.

To reduce the impact, the world would need to make greater use of solar-derived energy sources, such as wind, bio-mass, small hydroelectric plants, and photovoltaic facilities, while burning natural gas would be exceedingly useful as a replacement for coal during this earth-warming emergency.

It is also now apparent that the causal connection between carbon fuel burning and climate change is slow-acting and not likely to be catastrophic. Severe regional storms and shifts in rainfall, accompanied by a few reductions in the growth of energy demand, are most likely. Therefore, the conservation policies already initiated are still appropriate to cope with future uncertainties.

Byproducts of fuels used in metropolitan areas build up pollution levels beyond a tolerable level.

The sulfur in coal and petroleum becomes the air pollutant SOx, which is precipitated as acid rain downwind. Combustion of hydrocarbons at high temperatures causes a reaction with air to produce NOx, which not only adds to acid rain, but also catalyzes the production of photochemical smog from unburned hydrocarbons. Small articulates are correlated with more airborne disease than are the gases, which suggests that coal-fired electric power plants, diesel engines, and wood burners require better cleanup technologies.

Large stocks of natural gas sequestrated have been discovered in ice at high pressure and great depths. They are not yet equivalent to proved reserves, but they can be tapped at a cost that should be reasonable about a human generation from now when other low-cost fuels have been largely exhausted.

Technologies are being found for converting solar energy into electricity at costs competing with those for nonrenewable fuels, such as generators burning methane and liquid hydrocarbons.
In certain locations thermal solar plants and windmills are economical enough to contribute a large share of the capacity needed to meet urban power requirements, while photovoltaic arrays already serve the periphery of the grid, and biomass burning turbines fit into some of the minor nodes.

These alternative sources are vulnerable to volcanic eruptions or major storms, but such disastrous events are much less frequent than the effects of drought on hydroelectric power.

Substitutes for liquid hydrocarbon fuels for automotive vehicles have been developed to the point that they could be introduced by 2000 A.D., particularly for service fleets.

Natural gas itself can be used for short-range trips (two hundred kilometers per day), as can fuel cell vehicles to some degree.

Methanol can be made from vegetation, instead of ethanol, in sufficient quantities to handle the bulk of passenger needs when the shortages appear on the horizon, but there are worries about the toxicity of methanol spills when it is consumed in very large quantities.

A hybrid vehicle that combines engine-generator-battery, and electromotive gearing that will fit current road networks, could dominate automobile production after about 2010

Economists have routinely assumed that new energy resources will be found to fulfill the needs of future generations. This is a statement of faith, with no evidence being presented other than an extrapolation of long historical trends.

To specialists in geology and forestry drawing upon current data, this belief appears to be utterly nonsensical and improvident. Looking at a generation hence (2030), they see trends such as:

- reduction in the useful reserves of petroleum by more than half
- coal and gas by one-third
• forests by half
• arable soils by 10 percent

while the urban population is expected to rise by 70 to 80 percent in the same period.

Geologists and foresters are frightened that the global energy pinch could cause massive deprivation leading to as many as ten million to one hundred million deaths from famine.

Mainstream neoclassical economists are serene about energy, though inflation and productivity concern them greatly.

Both sides of the argument are perceptibly wrong. These specialists have not consulted the new knowledge accumulating outside their own disciplines that affects energy utilization and energy supply practice. They have failed to take into account such factors as demand-side and supply-side management.

Demand-side management involves the dissemination of techniques of energy conservation that are acceptable to consumers because the changes result in no loss of convenience and sometimes even produce improvements.

This approach will be very high-yielding for the next quarter century, with savings of 50 percent of projected energy demand introduced at costs for system modification much lower than the long-term price of energy; thus the profit incentive works, and a small amount of new regulation beyond standards setting is needed.

Another 50 percent of the remaining energy demand can be reduced if crude oil prices go higher than $40 per barrel (Schipper, Howarth, and Geller 1990, ___ and Lovins, 2000). The potentials for savings are as great in the developing world as in the highly industrialized countries, but they will take longer to implement.

Supply-side management involves regulation over competition among sources of energy. Energy supply to electrical grids has been highly regulated by governments for reasons of public safety and to prevent monopolistic gouging.
In most developing countries electric power supply became a state monopoly, subject to:

- acceptance of political appointees
- petty corruption
- subsidies for voting consumers
- slow adjustment to technological change

Beginning in the 1990s manufacturers of expensive generating equipment collaborated with the engineering contractors and international finance providers to create the build-operate-transfer (BOT) option to take advantage of recent innovations that could still fit into traditional views of state capitalism.

The economies involved in converting a natural resource like coal or natural gas, even if it is bought on the world market, into delivered electric power are seldom revealed, but are likely to show a 20 to 50 percent improvement over 1990 averages.

The introduction of supply-side competition for wind, biomass, photovoltaic, geothermal, and solar thermal energies through modern regulatory procedures can be almost as effective, but their technological changes introduce risks of loss from investing in excess capacity.
Chapter 5 Section Four

Transport Economies

In a poor city, transportation is a greater hurdle than household organization, because of the attractive image of the automobile.

Members of the elite and some in the professions feel that possession of a car and driver will exhibit their elevated status, while for others, careering around in a personal vehicle demonstrates freedom with power. However, despite low labor costs, only a minor fraction of the residents of poor communities can afford a vehicle.

What is meant by poor in transport terms can be illustrated by an example from a city in which per capita consumption is less than one dollar a day.

In 1991 Dhaka (a city of seven million populations in Bangladesh) had perhaps four hundred thousand human-powered cycle rickshaws providing short-range taxi-type trips and parcel delivery service. The number is uncertain because many rickshaw operators have fake licenses. The fuel for these vehicles is food -- sugar in the tea and oil in chapattis (fried cakes), amounting to an extra one thousand to twelve hundred calories per day per "rickshaw wallah" (operator), for an estimated thirty to fifty passenger-kilometers of service.

The rickshaws create some unusual traffic jams in the better paved parts of the city, partly because there are few places to park. An even larger number of bicycles are much less visible because they are generally on the streets only during commuter hours and are stationed off-street the rest of the time. Buses are useful only for connecting peripheral towns, because traffic delay in the city is so overwhelming.

In addition, Dhaka may have eighty thousand "baby taxis," which are scooter-powered, two- or three-passenger vehicles that can also connect the metropolitan fringes effectively. Improved designs are appearing, but none has reached the quality of ride and appearance of the propane-powered Bangkok "chuk-chuk." The city also has jitneys on high passenger flow
routes, minibuses, and a few buses, but it supports relatively few public or private automobiles.

Redesigns of these vehicles will provide more dependable service, less air pollution, and reduced noise, but not much saving in energy consumption. Economies brought about by better-maintained streets are believed to be considerable, but are not readily estimated.

Ferries and other watercraft are particularly important during the annual flood season. Taking all the modes of transport into consideration, Dhaka could well evolve into a city that operates on the lowest possible expenditure of energy, because it is truly flat, and it is less psychologically dependent upon private autos than any other major metropolis.

Policies for reshaping the existing transport systems for poor mega-cities have been adroitly assembled by Gakenheimer (1994). His six strategic objectives for an urban transportation system can be paralleled by use of the suggested indicators:

- Pricing and financing (cost per trip and travel time)
- Choice of mode combinations (capacity constraints of technology)
- Control of the invasive use of automobiles (vehicle population in circulation space)
- Mobility for the poor (land planning for high residential density, low unit costs, appropriate pricing)
- Environmental protection (air pollution levels, extending life cycles of public treasures)
- Competent institutions, continuously renewed (introduction of ratios of service provided per unit of scarce resources)

The hierarchy of transport technologies, even in a poor metropolis, will ultimately require high-volume speedy rail service, international airports, and container ports.
Water Market Accounting

Water is a renewable resource whose management has no equivalents of the iron laws of thermodynamics.

An entropy law says that water tends strongly to run down slope, but pumping it up is included in the energy accounts. The most significant aspect of water accounting, the limitation upon carrying capacity, has been taken up in chapter One, with examples.

Budgeting water becomes a matter of survival for the community when water is truly scarce, but otherwise it is treated almost like a free good.

Remember, also, that too much water can become a threat.

When floods are imminent, communities must defend themselves. Indeed, they are comfortable with only a threefold range of flow-through. Energy and close attention must be used on either side of that band to prevent casualties in urban settlements.

The supply side of water accounts begins with rainfall and snowmelt in the part of the watershed having runoff dedicated to irrigation of intensive crops before reaching urban communities.

Therefore, rainfall forecasts are introduced and stream gauges scattered through the water collection terrain.

Tributary upstream watersheds are hilly or mountainous, preferably forested to reduce erosion. Correlations between precipitation and flow make it possible to forecast a few days ahead of time the amount of water that can be collected by reservoirs.

Hydrologists are concerned about erosion, because it will cause the reservoirs to fill in a matter of decades to centuries. When reservoir capacity is reduced by silt accumulation, risks of suffering from droughts and floods increase.
Accounting for urban water begins at the reservoir, and the projected water level in it is the best indicator of available stock. It has valves that deliver the water into the distribution grid, which then delivers to the consumer-actors in the city.

A plan for accounting for future water supplies begins with information that is needed to play a game against the weather. Long-range weather forecasting has been slowly improving, so the amount of runoff can be estimated with a moderate amount of confidence. That figure can be converted into an interruptible water flow supply to be contracted or bid for on a futures market. The prices paid would normally sustain the regional water collection system and allow exchange with adjacent reservoirs in neighboring watersheds that are experiencing different problems.

Farmers growing intensive crops for local consumption are expected to be the major bidders in the water market, but landscaping managers for major institutions and parks are likely to enter into competition.

If there is poor weather, the early bidders would be granted an opportunity to resell part of their contracts. Individual large-scale water users could then bargain with each other, buying and selling quotas. Incoming industries would naturally negotiate with the water authority, which may construct facilities for increases in collection of runoff. A long-range growth plan will anticipate new users.

Almost all industries are very concerned with the year-round dependability of water supply and water quality.

Management of water quality remains quite perplexing. While trickling through the watershed, the water will accumulate salts and traces of toxins from the soils.

In a few instances a treatment process must be installed so as to meet minimum standards for raw, filtered water. Decisions to treat or not to treat will require continuing reports on water chemistry. Much more troublesome are the "non-point source" pollution incidents, which occur when major rainstorms wash down animal and human feces and fish-killing pesticide residues into the streams and ultimately into the reservoir.
Methods of treatment exist for these situations, but the cost in land area and processing is usually incommensurate with the marginal value of the water.

Up-to-date appraisals of the new technologies and the policies by which they can be put to best use are presented in the monthly *Environmental Science and Technology*. The policies and technologies discussed in the publication are almost entirely restricted in relevance to North American conditions, but the scientific reports have universal application.

A major competitor for the reservoir in many lightly urbanized parts of the world is groundwater. Water obtained from wells and springs is often said to be naturally "mineral," and occasionally is not potable. The groundwater may accumulate nitrates from the heavy use of fertilizer in agriculture, and solvents and heavy metals may enter from industrial establishments. Most estuarine cities can tap deeper aquifers that are recharged by fresh water from higher altitudes in the watershed.

If these aquifers are drawn down too vigorously, the pores containing the water are crushed by the overburden and the overlying earth sinks. As a result of depleted groundwater,

Bangkok is sinking below sea level. An alternative threat is the puncturing of the underlying clay strata protecting the aquifer, whereupon salt water intrusions affect portability.

Shanghai, Jakarta, and Manila have also had to take strong measures to limit pumping of groundwater.

Too much water brings with it drainage problems. Civil engineers have to be called in to design the drains. The data required are not general, but very special, so the sources and methods will not be taken up here.

**Demand-side Management for Water**

Examples have been provided in (chapter One), regarding how cities have rationed water in the Western world (Santa Barbara, California) and in the developing world (Hong Kong, Bombay, and Beijing).
The situations leading to rationing in these cities were almost universally believed to be emergencies, so arbitrary allocation procedures were politically acceptable.

However, the expense, as measured in deprivation and borrowing against the future, was high, so a superior approach is sought that is less threatening and painful, even though the actual supplies may be even more restricted. The answer lies in the planning of a distribution system that conserves water at gradually increasing marginal costs, not just in price but also attention, and designing households and management methods that strongly encourage saving water when the price rises.

Pristine virgin water coming from the upper basins through reservoirs and deep wells should in ordinary times take care of day-to-day consumption, but drought comes every three to ten years. Then recycled water becomes important for survival at a decent level of living. The greater the shortage, the more intensive the recycling of wastewater.

It is important to note that energy costs go up exponentially per unit of water delivered by intensifying recycling of polluted waste streams. The limit of intensification would be reached by a space station community, where the cost rises to levels intolerable on Earth.

Developing cities have to be very careful of extra costs, so it will be useful for planners to depict the set of technologies that seem to be most suitable in the long run, and provide the greatest flexibility for change at times of extreme drought.

**Natural Ecosystems for Sanitation**

Sewage is ordinarily collected from a city on the downstream side, and between rains very little runoff from the roofs and streets is added to dilute it.

Raw sewage in shallow ponds exposed to the sun will quickly be converted to a green or blue-green algae culture. The species of algae that predominates changes from season to season, but the yield in bio-mass, measured in tons
per hectare per annum, is greater than any found growing on land, and as a minor fraction of the ponded sewage evaporates. The feared bacteria and viruses causing cholera, dysentery, and some less prevalent diseases, completely disappear after two to five days of exposure to this high-tech algae growth.

Fingerling carp or tilapia can be carefully introduced to consume the algae, thus converting them into fish flesh with a caloric efficiency of 10 to 25 percent. Young fish also find the larvae of mosquito's delectable, so that an otherwise marshy district is well protected from malaria (an increasing scourge since the 1980s). These ponds can be kept odorless, except possibly under extreme conditions (Figure 5-1).
Figure V-1. Future Metropolitan Water Supply. Water commodity specifications should be appropriate to use, metered, and sold at approximate cost. A properly designed city should be able to function for a year at the most highly reduced level.

Occasional dehydration is preferred to becoming a drought refugee.
Natural predators invade the ponds, but they can be kept in control by putting ducks on the surface, and harvesting both their eggs and meat. The water can go from the ponds to the irrigation of intensive market gardening, or to a rice field that grows zooplankton in the flooded paddy before releasing its culture into a brackish pond near the edge of the sea that has been seeded with precursors of tiger prawns.

All this is already done piecemeal on a mass scale in out-of-the-way villages on tropical estuaries in several parts of the world with the aid of local experts. An alternative would be to filter the fish pond effluent and recycle it back to the urban raw water distribution system.

Arrangements like the one depicted in (Figure 5-1), are based upon hundreds of years of experience in Southeast Asia with various subassemblies of the integrated system.

That technology has now been rationalized through a choice of the most efficient species and design of economical physical equipment, so that the yield can be multiplied fivefold or more over early experience. Pollution from animals such as:

- pigs
- chickens
- cattle fed in batteries of pens can be treated in the same manner as:
  - streams
  - canals
  - bays (Meier 1994).

Because this sewage recycling process uses sunlight (which falls upon low-valued open space fitted to receive it), it is infinitely superior to power-intensive Western procedures for recycling water from sewage. Its one drawback is that the value of the total product is insufficient to pay land rent in the heart of a city.

Low-rent dwellings and food-processing industries do not belong in central places, although they are often trapped there by rapid urban growth.
Homes and businesses will respond to the same incentives for saving water as for electric power and gas. If the water is metered (surprisingly it is not yet in the so-called Third World cities, due to the high cost of old-fashioned meters as compared to the cost of water), consumers will economize when the price is high and if the plumbing allows it.

Wash water, for example, can be filtered locally and recycled. Low-grade gray water from food processing and the laundry might be used to flush sewage. The toilet flush size itself can be reduced to five liters instead of fifteen to twenty liters. Under a regime of water scarcity, people can learn to live cleanly and quite comfortably on fifteen gallons per day (50 liters) net. City water in developed countries is chlorinated to prevent dysentery, and frequently fluoridated to inhibit tooth decay, before it is distributed to consumers.

The conclusions regarding water accounting are relatively simple. When a surplus of water is on hand, the quantities need to be known (perhaps within 20 percent) in order to manage the drainage effectively and to minimize flood damage.

Weather forecasting can be extremely valuable in this kind of urban management, because the sizes of the storms introduce different threats to the continuity of urban operations, and warnings will usually prevent serious losses.

At least 90 percent of the time ordinary levels of water inflow will be experienced. It should be priced so that the urban infrastructure can routinely supported from the revenues. If comprehensive recycling of urban wastes is undertaken, some lower-quality water commodities will be produced, such as some sewage and food-processing wash liquors.

Sunlight for these treatment technologies is the principal energy source. Energy is paid for henin the form of rent for convenient adjacent ponds and gardens. The fish, ducks, and vegetables produced as byproducts should provide enough food and feed to pay for the extra equipment costs.

If individual household and small enterprise consumers can be metered economically, the simultaneous creation of a water market for several
qualities of water would be advisable. Water management for a very poor city will require some innovative planning to diminish the high costs of crises.

The usefulness of a quasi-market for water with futures options is greatest in times of drought and other events causing stringency in supply. A high enough price then becomes the capacitating stimulus for water conservation, if exhortations over the mass media are ignored. Pricing is administratively more flexible than water rationing.

In times of high prices the peri-urban agriculture would avoid thirsty crops like:

- rice
- sugar cane
- alfalfa

and concentrate instead on drip-irrigated:

- roots
- tubers
- vegetables
- fruits

Landscaping could be starved of irrigation, if it were planted with a realization that occasional shortages would be likely. An urban community must be able to adjust its water needs to the prospects for supplies.

With water accounting in place, designers of buildings would be able to justify the choice of plumbing that allows quick adjustments to price changes.

The absolute minimum domestic consumption that can be achieved, while still keeping the city functioning, seems to be 10 to 20 percent of normal consumption over a period of several months, but meeting that target requires buying out agricultural rights for irrigation.

Failure to plan for this contingency would generate drought refugees, or impose emergency withdrawal from energy stocks for water upgrading, including desalination, or for direct import.
Materials Sufficiency through Substitution

The present methods of analysis for the chemical elements are very sensitive and are widely applied, so that the maximum casualty rate from toxic events, such as for lead, mercury, and plutonium, has been kept below the level of the worst airplane disaster.

Millions of different molecules that are stable at ambient conditions have been isolated or synthesized, although even more remain to be found or prepared.

Hundreds of thousands qualify as foods, so they are consumed through digestion, with some of their energy content stripped, and the remaining molecules are excreted.

Tens of thousands of natural toxins have been created by species in nature as measures of self-defense (Ames and Gold 1991), while thousands of specific compounds have been specially designed by chemists as pesticides, selective for predators.

These special kinds of molecules make up a list of pure foodstuffs, vitamins, and other health-inducing compounds, as well as suspected toxins and proved toxins, mostly carcinogenic and mutagenic, maintained by the U. S. Food and Drug Administration and its Environmental Protection Agency (which act as pacesetters for the rest of the world).

Not infrequently animals are affected differently from humans, and plants have still greater variations in response. As knowledge increases, the lists of special molecules lengthen a few percent per year.

However, a greater number have their significance changed by the discovery of:

- proper dosages
- adjuvants
- antidotes
- reinforcing influences
These accounts are managed principally through standards setting and health management relabeling of packaged foods and drugs.

Societies and communities have placed controls over the import and export of politically critical materials, and have put into operation surveillance procedures affecting transactions that distribute them.

This policy can restrict the flow of materials such as cocaine, heroin, cannabis, and other hard drugs, as well as plutonium, radioactive materials, and bio-toxins, thus requiring materials accounting for legitimate transactions. Some societies find that a few substances are deleterious to households and communities rather than individuals. An example is India’s ban on gold imports -- moderated somewhat in 1990s - because of its citizens' fanatic involvement in the dowry system, as well as gold’s role as a tax evader’s favorite commodity.

The remainder of materials flows takes the form of bulk commodities. Orderly markets require measures of production, agreement on standards, consumption data collection, and inventory storage, together with open publication. Grains are followed closely as a means of famine prevention, while cement flows strongly to communities experiencing rapid physical growth. Comprehensive information is collected to prevent scandals when cliques of speculators try to manipulate the market for monopolistic profit.

We can conclude that institutions for managing materials accounting in developed countries seem to be in place.

Shortages felt by consumers of one commodity almost always can be filled by substitutes made from other commodities. All systems of supply need reform and updating, but only in the area of hard drugs has there been widespread breakdown. Fundamental policy changes will be made necessary by the discoveries regarding specific new molecules that cause trouble.
Nuclear energy suffers from a bad press.

The recorded accident rate is much less than that experienced with the coal-fueled power system, but the public image of nuclear power plants is so bad that most people do not believe the published numbers, since their reliability is always impugned by some self-appointed experts.

Feasibility of nuclear power started to be discussible again in the background with the onset of power shortages in 2001-2, and extended records of trouble-free operation. Nuclear power plants are nevertheless vociferously opposed by their neighbors (a familiar NIMBY--not in my backyard--phenomenon).

Nuclear power generation, when properly designed, has been safer even than solar energy, but again, because these data are contradicted by the formulas by which headlines are produced, the public assumes the data must be faulty.

This is an instance in which accounting techniques applicable to choosing the lowest cost proposal among alternatives are irrelevant, and may remain so for a long time. Meanwhile, reactors with a safer, more efficient third-generation design will only go into use in the few places in the world, such as West China, that are so isolated that public opinion has not caught up with the rest of the world.

When the total of documented risks to health from:

- NOx
- SOx
- CO2
- airborne particulates
- radium
- mercury
- mining
are recognized, they are likely to exceed those of radiation from nuclear power reactors in northern latitudes.

The appropriate accounting technique for justifying the use of nuclear power is a vote of public confidence, such as might be obtained in France, where nuclear has been a principal source for decades. Meanwhile, solar-based sources of electrical power are ready to meet the extra energy needs of most cities (Johansson et al. 1993) at little extra cost.

Prospects for the Twenty First Century

Converting mass into energy by means of nuclear fusion, in the manner of the sun, has long been a dream of physicists and nuclear engineers.

The public objections to nuclear energy and its radioactive byproducts can be overcome by at least 90 percent. After investment of several billion dollars into R&D (research and development), practical fusion is still a dream, but the hurdles are much better understood.

Theoretical potentials for using the deuterium in the oceans as an energy source are so attractive they cannot be ruled out for the long run, but even the most ardent enthusiasts for fusion energy do not promise any output before the year 2050. Appraisals of further developments in this technology are likely to be found in the Bulletin of the Atomic Scientists.

One of the remarkable visions of the 1970s for capturing energy from the sun was that of the space scientists, who proposed to take advantage of the observation that photovoltaic cells would be twice as efficient in outer space. It had already been demonstrated by experiment that the collected energy could be transmitted in focused microwave beams to the cities that needed energy.

The energy would be received by antenna made of thin wires suspended over a green open space of a few hundred hectares, and transmitted to the grid during the peak twelve to thirteen hours per day, or longer at greater expense (Glaser, Davidson, and Csigi 1998).
Environmentalists immediately raised objections to this proposal for solar energy from photovoltaic cells. However, the vulnerability of humans and pigeons moving through the beam of microwave radiation was shown to be trivial by experiments with radar that had begun during World War II. The contribution to earth warming was shown to be very small, and it could be counteracted by changing the reflectivity of metropolitan areas, by means such as coating the asphalt in roofs and roads with white titanium dioxide pigment, which has other redeeming benefits.

However, the economical launching of space stations dedicated to collecting solar energy for a metropolitan grid seems to require a moon colony that mines, refines, and fabricates lunar matter for both the photovoltaic cells and the backup equipment.

A National Academy (U. S.) Committee dashed the hopes that had sprung up by demonstrating that the expenditures required for such a station were equal to those of a small war. But cost diminishes with technical progress, so solar space stations are presently judged to be an even more satisfactory large-scale solution to the problem of energy supply after 2050 than fusion energy generators.

**Strategies for Energy Conservation**

**Energy Saving Site by Site**

Once the "big picture" for energy has been outlined, it is possible, and necessary, to review energy accounts at the level of the household and the design of buildings.

Huge savings can be made by changes already seen in the former energy requirements for sustaining urban life. About half of the reduction in energy consumption projected two decades ago has already been achieved in the pace-making metropolises. Lessening the cost of energy production and distribution is targeted, but it may take more time.
Urban consumers living in cities with the most advanced technology use ten to thirty times as much energy for assuring their comfort and convenience as the two thousand to three thousand calories required for daily nutrition.

The demand-side management option promotes careful design and attention to waste. Consumption can be reduced to three to five times the nutritional needs, after measuring the energy required for each activity and considering the alternatives offered by the latest technologies. Nowadays this is accomplished by developing computer simulations that trace energy, water, and human time expenditure day by day, season by season, through typical buildings and vehicles.

Design changes that promise system savings would be selected, and then followed up by testing the innovations in the field.

Designers who fail to undertake extensive field tests of their innovations should expect to be surprised by crotchets of human behavior that are almost inevitably wasteful.

The magazine *Home Energy*:
- appraises these innovations
- reports on the efficiency of appliances and appurtenances
- reviews the software
- describes the strategies of implementation through retrofitting existing structures

Sophisticated designers would have to go to the theory underlying the software and work out their own optimizations, taking into account consumer preferences, the site, and the scarcities in the region expected during the life cycle of the building.

Planning requires asking, “What are the salient characteristics of buildings that, it is now believed, will fit a sustainable society a generation or two hence?”

This design exercise will start with the Western city that has to cope with standards and expectations that carry forward from the present.
Imagine first an urban site that is served by automotive-electric vehicles that are either personally owned or rented.

The building would be super-insulated in all but the mildest climates, or else earth-sheltered.

The windows would be double-glazed (or triple in the coldest latitudes), and coated so as to admit visible light into the building, but not the ultraviolet wavelengths.

Infrared wavelengths would be admitted in the winter and excluded in the summer, perhaps by turning the window inside out.

Remaining energy in daylight would be absorbed during the daytime by walls and floors and allowed to radiate at night to assure a comfortable internal environment.

Light could be reflected to a ceiling that refracted it a long way back from the sun-facing wall and as the sun set microprocessor-controlled fluorescent lights with equivalent spectrum would replace it.

Light pipes that follow the sun across the sky to collect the maximum light, which can then be diffused into the interior of the building, could keep all areas highly livable.

All of these features would need energy-accounting systems to optimize the size and the specifications.

In the energy-efficient building of the near future, landscaping would be carefully adapted to solar apertures and the wind regimes so as to protect the building from extremes.

Circulated air would be introduced through heat exchangers that extracted most of the heat of the rejected air.

Appliances for temperature control, such as furnaces, air conditioners, and refrigerators, would be used minimally and shared most of the time with others, while ventilation would be engineered for comfort.

In an apartment house, for example, a household might rent one to four trays in a common refrigerator facility that serves a whole floor. Residents would take one or two trays at a time to the food-preparation zone of the dwelling unit, thus greatly reducing the door-opening losses of cold air.
Cooking is most efficiently done with microwave, but where baking or roasting is preferred, a bakery-delicatessen (like an ultramodern pizzeria) should be available to provide the service. Metered hot water may be drawn from storage tanks heated by solar energy, or as a co-generation byproduct of electric power production.

All this would be worked out on a simulation of heat and power flows before construction begins, and it should be redone in a post-occupancy study, because habitual human behavior can change optimum settings strikingly.

The massive new immigrant populations settling in the tropical cities of Asia and Africa cannot afford this level of capital investment.

An exercise in synthesis, using a parallel mode of energy/space minimization, and applied to the climate and culture of Bangladesh one of the very poorest counties, for the first and second generation in the twenty first century. It argues that the degree of comfort and convenience of the West can be approached through design at about 10 percent of the present American energy consumption.

That would provide sufficient human time and freedom to elaborate as complex a culture as that of Athens or Osaka (Meier and Quium 1991). The ultimate criterion is the opportunity for residents to conduct a quality of life competitive with that in other cities, not just superior to the countryside.

Planning for energy conservation in poor cities begins with lighting.

Newly electrified homes give lights the highest priority because they extend the lives of humans and artifacts about 30 to 40 percent by allowing activities to be carried into the dark hours, thus greatly expanding the numbers of public transactions.

The lighting of public places requires neighborhood organization, but it normally follows electrification quickly. Therefore, simultaneous with the provision of electric power should come compact fluorescent lamps and convenient fittings. Retrofits of previous illumination should be expedited so as to displace energy-wasting incandescent lamps.
The same service level of lighting will cost less than half with new lamps and fittings. Lighting demand is responsible for 25 to 35 percent of the total power consumption in poor cities today (Sathaye and Gadgil 1992), but when illumination is cheap, more will be used to obtain greater personal efficiency. (Goldemberg, 2000).

Refrigeration for food preservation and air conditioning comes next.

The new economical units require 30 to 35 percent of the energy of their predecessors. Producing and distributing the new designs, with payment schedules to fit the pockets of poor people, will take careful market research.

Demand for comfort and convenience follows, so electric fans and air conditioning are being subjected to the same kinds of redesigns (Sathaye and Tyler 1991). Television and computing, particularly recharging cell-phones will be introduced conjointly with microwave cookers, but digital television will have a continuous demand equal to only a few lights, and microwave units similarly.

For all this to happen, a new kind of accounting will have to be introduced:

The social costs of the "energy saved" for that urban region will have to be estimated and compared to the costs of the energy supplied. After distribution networks and power-using equipment have been redesigned, together with computerized power markets (not an insignificant design problem for economists and engineers), the least-cost outcome is expected to bring installed capacity of electric power down to the order of 0.1 to 0.2 kilowatts per capita.

Compare this to the presently projected 0.8 to 1.5 kilowatts per capita in affluent societies. This considerable saving can occur gradually as the lifetime of the hardware currently installed suggests replacement.
Chapter Five  Section Six

Water Futures

The supply of water on Earth is determined by the Hydrological Cycle. Water vapor swept from the oceans and vegetation. Condenses into clouds in the upper atmosphere. Then small droplets form around particles of dust, which consolidate to snow or rain. Still as pure. Soluble salts in small amounts are collected from erosion and percolation before it arrives in reservoirs and underground aquifers, almost always potable. The source of energy driving the cycle is the sun.

Cities have a propensity for creating monopolies in water supply. What does a city service do when it foresees a major deficit? They used to buy out a neighbor that was less vulnerable, but now they learn about inventors and contractors who promise to supply needs with plastic bags.

A tugboat could go out to the nearest river mouth pouring uncontaminated water into the oceans, fill up a string of bags, which will expose their tops to the surface as if alive when moving, and named "dragones" (sea dragons) in the Mediterranean. This technology is cheaper than desalination of seawater, and requires less capital and fuel.

Capturing an iceberg, and using the harbor as a convenient reservoir of melted water would also be discussed, but it has not happened so far.

Regional urban ecosystems are comfortable with a threefold range of flow through volume between too much and too little. Assuming customary flushing of waste.

When water ceases to be treated as a free good, a gift of Allah, several commodities emerge beside tap water, which are valued according to supply and tolerance of different degrees of pollution by classes of users, the poorest of which has negative value and requires effort and attention to destroy in a scientific manner.

The water commodities have evolved technologies for upgrading, so that a high degree of recycling within the metropolis now available when water
prices are high. Fig 5-1 Thus, with these technologies in place, and an informal market in operation, the city can within the present state of knowledge, become a rational, smoothly adjustable ecosystem.

This observation would be true, were it not for certain taboos held in Western peoples about dirt and its adjective "dirty". Words for different forms of this image are banned from popular dictionaries, and the sight and smell are treated with horror.

European and American publics are especially phaecophobic, to the extent of wasting billions of gallons of perfectly good water produced as effluent from sewage treatment facilities with a measured purity superior to river water, but tainted only by knowledge of the source. The water crises called "shortages" will almost always be traceable to such non-scientific beliefs, unless the water itself does not arrive.

A deficit in rainfall called a drought can cause a really serious shortage. They are more prevalent in the interior of the continents. Until now the antidote to a drought has been an enlarged reservoir, preferably underground, because that sitting resists evaporation.

Cities could not grow large in drought-prone areas, because small settlements would be abandoned after two years of severe drought, and after three, the cities also. People flee to greener areas, hoping to return when the weather is more propitious.

A frequency of three droughts per century is enough to clip the new growth from cities in a drought-prone region, so the surplus people must migrate further.

- Reviews of the most recent technologies (Meier, 2002) shows that it is now possible to construct a green metropolis in a place with such a climate by
  - (1) replacing the flush toilet with a dry process adding activated clay to repress the smell and flies
  - (2) diluting the urine in water for intensive kitchen window gardening of fresh produce
• (3) job-sharing with training
• (4) packaging the water for human life and work and selling it retail on the street. And otherwise adding to the education and training of the drought refugees, enabling them to live comfortably and conveniently in this novel urban environment.
Chapter Five Section Seven

Budgeting

Budgeting Time and Life

Life is prized by the living, and it is often shorter in duration than desired, so living things have learned to conserve time.

Universal measures of time begin with the motions of the planets (days, years, and glacial cycles) and apply these units to all the consumers in the community.

The relative value, priced in money units, set for the use of time is derived from:

1. the efficiency of work
2. the psychology of the individual
3. the judgments of designers of artifacts
4. the demands for cultural participation
5. conditions of stress in individuals and organizations, with their attendant needs for mental and physical relaxation.

A lifetime for humans is a kind of endowment. It is an aspect of living that is allocated to the individual's different needs and interests (Szalai 1972; Fox 1985; Robinson and Godbey 1997).

Part of a person's time is taxed by the society, which imposes obligatory duties:

- military service
- licenses
- voting

and another part by the community:

- elementary education
- attending meetings
- qualifying for more licenses

Part is contracted out to employers in order to receive wages and salaries, and a much smaller amount to non-governmental, nonprofit organizations to
obtain services (e.g., churches, political groups) (Boulding 1977). Frequently
time is invested in training, with the expectation that it will save time later
(writing clear prose, practicing on a keyboard facility, computing, etc.) in
highly valued transactions.

Some part of each person's allotment of time is lost in space-time friction
(commuting, queuing, etc.). Economic value is seldom applied to time outside
of the measurement of labor, and double-entry bookkeeping seems to be
irrelevant (Carlstein, Parks, and Thrift 1978; Robinson and Godbey 1997).

Sample survey techniques allow us to discover how human time is actually
spent, particularly in urban environments (Chapin 1974; Hagerstrand 1972;
Moulton 1979; Robinson and Godbey 1997).

They can be applied as well for determining the duty time of machines,
occupation time for buildings, and operating time for organizations. There is
one difficulty, however.

Sociologists usually assume that only one kind of activity can be carried out
at a given moment, while psychologists recognize that attention can be
segmented so that a person can do two, three, or more things at once, some
of them subconsciously. Sampling over the segments of the population, the
days of the week, the holidays, the seasons, and the year gives a
representative picture for a region or a society (Miller 1991).

Interviews, diaries, and simple audits are sufficient, wherever people wear
wristwatches.

Contrary to common belief, Americans tend to work more hours per week
than the Japanese; this misconception probably stems from two facts: that
much homework in Japan is not called work and that labor force
participation of women is greater in the United States. But commuting
takes longer in Japan, so Americans (in 1990) had an average of forty-one
hours per week left over after work, while the Japanese had forty. Table
5-1 shows how the Americans allocated their time. The growing American
trend is to schedule "quality time" with family members and close friends.
Mass broadcasting is particularly vulnerable to substitution, since specialized forms of television and Internet participation are growing rapidly in popularity, starting from a small base.

Literate, urban societies are much alike in their allocation of time. The poor have much less free time than those who are better off, because so much is spent "just waiting" for work or for services at clinics and welfare stations.

The smallest amount of discretionary time for any population segment in the United States was available to black mothers between thirty and forty years of age, who struggle to keep a household together against overwhelming demands.

The quality of a person's life seems to depend heavily upon both the amount of leisure time available and the freedom available for using leisure time. "Hanging out in the mall," for instance, gives young people a chance to explore consumer options, although strongly disapproved of by the educated classes.

An accounting for time is fairly easy to carry out by asking people to keep diaries and rewarding them for completeness. For less literate segments of the population investigators can interview sub-samples, asking them to report on how they spent their time the previous day.

A difficulty turned up among very poor, illiterate urban workers, because they could not distinguish "yesterday" from any other day, so field observers found it necessary to report upon what they seemed to be doing.

One technique employed by sophisticated investigators who were worried about the validity of self-reports was to provide workers whose time was of greatest value (and therefore was most worth saving) with wristwatches equipped with alarms that sounded at random times, thus allowing for truly random sampling.

When the alarm sounded, the worker was to record what he or she was doing at that moment. That method produced quite consistent data, until it occurred to the investigators that when the alarm went off the person could be asked to report on the person at the next desk, instead of himself.
External reports deviated from self-reports by more than 20 percent. The explanation seemed to be that what looked like relaxation to the outsider was called mind work, planning, or calculation, and therefore legitimate work, in the self-reports.

Another kind of bias showed up in studies commissioned by home appliance manufacturers who wished to discover how much time their appliances: washing machines
- dryers
- refrigerators
- vacuum cleaners
- air conditioners
- electric stoves
- electric lights
saved the people who used them. The time that is saved by significantly increased efficiency in one aspect of life is then distributed among pretty much the same categories as before. Therefore, after a major improvement in the experienced quality of life, the ultimate pattern in the time budget is hardly distinguishable from that which came before.

One thing does change, however, and that is the number of public transactions completed per unit of time (Meier 1968). Gottmann's (1983) observations on the megalopolis revisited suggest that both the number and the variety of transactions had markedly increased over the prior two decades.

For the designer this means that the fit between the facilities and the demand must have been improving.

**Aggregation of Transactions for Measuring Progress**

The patterns of human time allocation can be obtained relatively economically, but they do not contribute much to planning and design beyond serving as a corrective for money. One of the great challenges in ecological accounting is to obtain measures of the number, distribution, and diversity of transactions per unit of time. These measures should incorporate into a few indexes for a set of multidimensional indicators of
improvements in quality of life. Transactions combine economic, social, cultural, political, environmental, and health interests in a compatible and much less biased way than money accounts in cost-benefit analysis that have been revised to meet environmental critics (Goodland, Daly, and El Sarafy 1992, 1993).

A huge effort has already been put into the revision of the gross national product type of accounts (World Bank 1997), but even under the best conditions, they seem to retain so much ambiguity they cannot point the way to sustainability.

The central problem with the current environmental economics approach is that information flows and public knowledge stocks have been largely left out of consideration. This shows up in an inability to find a satisfying logic for adjusting discount rates so as to give some calculable weight to the welfare of future generations. Pearce, Atkinson, and Dubourg (1994) suggest that some projects should be financed to counterbalance this bias, but they give no example.

A fair suggestion would be to invest in education (information dissemination) and R&D (knowledge production).

Judgments based upon recent history in these directions offer appropriate lag times in yielding returns to society:

**Expected Lag in Payout**

Training (skill production in scarce specialties) 5-20 years

Education (advance to higher levels) 15-40 years

Development Investigations (new technology) 10-40 years

Basic Research (new concepts) 20-100 years

Ecological accounting must advance beyond environmental economic accounting. It needs to be constructed so as to catch those parts of
information flow and storage that can be affected by community organization and social policy.

Transaction counts do this very nicely. Should a troubling mistake be made, an important category of transactions would come out frequently with win-lose consequences, and members of the community would increasingly refrain from completing such transactions (unless they were addictive, whereupon the community or the society would organize to intervene).

If substitute transactions were lacking, the rate of interaction would decline, thus signifying a diminishing quality of life. A totalitarian ideology that restricts many options should induce a much smaller volume of transactions than other societies with similar levels of consumption of energy and materials.

The telephone has been a great boon for increasing the number and diversity of transactions. With the aid of:

- "yellow pages"
- answering machines
- toll-free services
- fax transmissions
- cellular networks

a variety of specialized community services were expected to be embraced (Meier 1983). The range of technological and user-oriented innovations ready to come on the market, and adding to diversity, is large and confusing to say the least, but several of them will very likely be seized upon by the public as important conveniences. Therefore, elaboration of telephone channel use seems likely to continue indefinitely, despite the complexity of burgeoning voice mail.

Note that in a poor or authoritarian society (these properties very often coincide):

- distribution of telephones is thin
- system noise is difficult to overcome
- number of calls per day is low
- content of the calls is restrained by the possibility of being overheard by police or censors
In the most advanced societies the number of calls per user is growing more than 3 percent per year per telephone, and in the most active metropolitan regions it is approaching one hundred calls per day. There has to be a limit, even if the duration of the call has been streamlined because of lack of time in the waking day. Sociologists reviewing time budgets would guess that 100 to 150 calls per day, with the aid of answering machines and voice mail, is a maximum for an individual, so it would seem that some cities are already close to saturation.

Technologists plan to overcome this limit by having automata communicating to automata, first in transmitting commands and data, but later in many other ways.

Two generations hence, when the condition of sustainability must be more closely approached, there will probably be many more automaton-automaton transactions via cable or satellite than transactions between humans.

The principles of conservation of:
- energy
- water
- materials
- time
- space

point to using telecommunications networks for added transactions because, with the latest fiber optic cables and digitized television cable networks, there remains sufficient capacity in the electromagnetic spectrum to carry all the traffic and information flow desired.

Psychological stresses felt by people in organizations set the priorities for measurement of time. Stress is induced by a growth in intensity of activity that presses against human limits to respond. Without policy reforms for the interface between a human and a machine, the "technological fix" approach would create as many human problems, and errors, as would be prevented.
A Huge Boost from Computers

Use of the personal computer stimulated a huge change in American society, which started in the 1980s and is moving as a wave through the rest of world, with a lag time of only five to thirty years.

The personal computer’s introduction was touted as an innovation that would lead to a huge increase in efficiency for producing services. That had not been the case before the mid-1990s, because productivity gains in the services (which are primarily based upon transactions completed per worker-day) had been growing in the 0 to 2 percent per year range in the United States, while manufacturing (pushed by more automatic machinery) continued to register productivity gains as high as 4 to 6 percent per year, based upon market value of output (Drucker 1992). Most enthusiasts for information technology were puzzled.

What these observers may have forgotten is that the software prepared for computers is designed to greatly reduce errors that range from spelling and computation to designers’ specifications. Error reduction tends to save energy, time, and materials in manufacture, thus enhancing its efficiency, but it also promotes much more complex decision making by allowing people to review more kinds of information before deciding.

This outcome is a matter of quality, for which economists have no good measures as yet. The argument is made here that, although the number of transactions (decisions) per hour of work advances slowly, the quality has been significantly enhanced. Noteworthy advances in environmental and health indicators as a result of technological advances in manufacturing, to mention another aspect of quality, were observed during the 1980s.

A very significant feature of the 1980s and 1990s is the short life cycle of the software employed, which means that huge amounts of time were spent in training on the job.

Almost all of the office staff has been upgraded in terms of proficiency with equipment. Careful accounting within American offices has shown that education, delays, and troubleshooting connected with the introduction of
computers and new software cost 6.5 to 8.5 times the original price of the tabletop computer during its typical five-year lifetime.

The staff is then ready to use a computer with ten times its capacity (Business Week, March 5, 1995). We must conclude that the social learning curve is quite steep.
Chapter Five Section Eight

Information, Transactions, Social Indicators and Sustainability

The term information derives from a Latin root meaning form, shape, or to organize. Sustainable communities need a stock of information to become sustainable over the long run, and they also need a continuous flow from which to draw. Measures of information are excellent indicators of the socio-economic health of a community.

The simplest way of accomplishing this re-forming by information is by making a series of choices. The most efficient choice is made by dividing the universe of possible steps into about half the original number, and then inquiring whether the appropriate step to the answer lies within that half. If the answer is yes, keep on subdividing until the single best answer survives (this is the optimum strategy in the "twenty questions" guessing game).

For example, if a single key on a standard computer keyboard is chosen secretly as the target to be guessed, it should take the respondent no more than six or seven choices to discover the answer. Then the quantity of information obtained is said to be six bits for each key (seven bits when the icons in the upper case are included).

Information has a life cycle that can be traced back to the "big bang," the event in which nuclear particles communicated with each other through collisions.

As the universe cooled through expansion, the collisions became less violent, allowing molecular structures to form and later to aggregate. Lowenstein (1999) uses a cartoonized set of transfers and the artifice of a "daemon" (from Aristotle, Maxwell, and a succession of nineteenth- and twentieth-century natural philosophers) that sorts molecules by shapes that will fit together neatly or transfer energy.

To do this an increasing variety of mediating "messengers" or "catalysts" is employed. Within containers (usually called cells) channels were evolved to
guide the contacts, and webs developed to coordinate them in space. Larger cells processed more information by introducing more diverse messengers.

The messenger molecules within living organisms were called hormones (activators in Greek) when they were discovered around the beginning of the twentieth century.

This class of molecules includes now familiar substances such as adrenaline, testosterone, and vitamin D3. Later in evolution, peptides about ten times the size of these molecules, and then proteins ten to one hundred times larger yet, completed the design of components for independent, complex organisms possessing brains.

Populations of organisms, unicellular and multi-cellular, interact with each other and the physical environment to form a community, like a coral reef or a village, in the ecosystem -- a stage that Lowenstein's arguments did not reach, so this is a good place for an extending discussion to take off.

Signals using sound or light carry messages that coordinate life in the ecosystem; they are the best indicators of the quantity of life sustained. Information transmitted through transactions in the community is what needs to be sustained.

Curricula in the schools have not yet prepared most of the work force for the Information Era, but the changes are well underway.

The decade of the 1980s raised university undergraduates to computer literacy, and in the following decade the universities started delivering sophisticated new professionals to organizations at the frontiers to accelerate the rate of innovation.

Standards of performance for jobs in organizations have been raised by technology that has greatly shortened expected response time and prevented common errors. (However, no improvement was noted in the clarity of computer-competent professionals' prose--a traditional criterion for a high standard of education.)
Nevertheless, complex organizational tasks, such as design of a new model of automobile, can be completed in as little as half the time, and the new models exhibit fewer glitches. Accordingly, college graduates with operating and design skills in information technology have become the most sought-after specialists in the labor force.

Scholars should attempt to report upon health, social, political, and cultural transactions, in a manner parallel to the reporting of economic, market-oriented activities.

These counts can be obtained from trade associations, sample surveys, consultants to specialized industries, and indirect estimates based upon uses of key facilities, such as telecommunications and highways. An attempt to do this for the United States in 1965, when it was about two-thirds urbanized (Meier, 1968), has not been repeated.

It was then suggested that the utility of transactions-maximizing policy had greatest value in the area of urban structural reform, because it highlighted the low-intensity districts of the city that had been "left out of the loop" of discourse. That problem has been of increasing concern, and a variety of community programs have been designed to address it (Schon, Sanyla, and Mitchell 1997).

It is now much easier to make estimates of transaction rates by sector and in aggregate. Every part of the urban economy is monitored by computers for purposes of management, except for a majority of the outdoor activities.

There people interact with the environment in such a way that the experience is remembered. They also can meet other people who have left workplace or home for much the same reasons.

Rough estimates of outdoor activities can be made by sampling landscapes and facades on the one hand, and the populations engaged in them on the other, based upon their time budgets. A sample survey can then be conducted to determine what aspects of the experience made a deep enough impression to be recognized later as being a result of the contact. How much has been added to the human repertory of images by this experience with nature and the landscaped environment? The estimate is now possible.
Designers should take advantage of open space opportunities, such as playgrounds, to create imaginative artifacts and surroundings that generate spontaneous activity.

They will thus be speeding up the frequency of the more subtle, small-scale transactions between people, which are growing more rapidly than those that are regarded as purely economic, such as purchases or commuting.
Chapter Five   Section Nine

Conserving Attention

Attention: The Newly Scarce Resource

Human attention is likely to become the fundamental resource of civilization, and the conservation of attention is the basis for future design and policy evolution.

Higher organisms practice using their capacity to "pay attention" by spending it on trivial matters in the surroundings such as play, or assigning it to reflections upon past events, with only a small fraction invested in work, education, or human support maintenance.

Attention is stratified, as was observed earlier in the discussion of the uses of time, meaning that a person can attend to several things at once (multi-tasking). Evidence of the ways it can be subdivided is found in highly evolved artifacts, such as automobiles and television. Through personal trial and error, people learn to pay attention to several activities at once. Attention in this circumstance means readiness for perception, and it serves as a gate for incoming information. The capacity to receive information can reach several hundred non-redundant bits per second, but the capacity to transmit is much smaller.

Attention can be estimated from the portions of the human time budget that are allocated to communication. It is focused upon patterns, images, and their changes, which are conveyed as clusters of bits, but discussion of ecology of images is reserved for Chapter 6.

Destroyers of attention are readily recognized.

Lack of change in the environment allows a person’s mind to doze off and invent his or her own actions in the form of daydreams. A sharp noise, a physical prodding, or a recognized signal usually alerts an individual back to attention, bringing up adrenaline that induces readiness for action. Attention is needed to guide that action.
Noise in all its various perceptual channels -- light, sound, touch, and smell -- is also destructive. It reduces the inflow of potential information. Noise is a nuisance because it degrades perception.

Artists and designers are keenly aware of the properties of attention.

- Artists want to capture attention, and then hold it for a while.
- Designers take advantage of what artists learn and apply it to the creation of interiors and the selling of artifacts.
- Engineering designers must maintain the alertness of the operators of their equipment in order to keep it effective.
- Appropriate indicators are defined largely by designers, who will put them into specifications for the built environment.
Chapter Five Section Ten

Producing Moods of Serenity, Happiness and Delight

The Pursuit of Serenity, Happiness, and Delight

What do people live for anyhow?

Serenity, happiness, and delight may be identified as the prerequisites for a good life. Most people assume that the community is there to help them survive and be happy.

Individuals and households are in "pursuit of happiness," as asserted in the words ascribed to Thomas Jefferson in the American Declaration of Independence (Myers 1992).

That quest presumes that the members of a community already know how to improve the quality of life and have a strategy of some sort for doing so, but they do not know how to achieve it at minimal cost, because happiness has not been measured by designers. Money is hardly a major contributor to the level of happiness when the basic necessities are at hand—an observation that has been confirmed repeatedly (Diener, Diener, and Diener 1995; Diener and Diener 1996).

What does it take to improve quality of life in terms of expending energy, time, and space for living or maintaining human relationships?

Social psychologists do not ask questions in this way, but at a more fundamental level they have found that recent happy events for those interviewed contribute the most to their sense of happiness (Seidtitz, Wyer, and Diener 1997; Suh, Diener, and Fujita 1996).

That finding suggests a management task more than planning. It has also been reported that more people in the world are happy than unhappy (Diener and Diener 1996). How, then, might struggling poor communities, whose members are fatalistic, sad, or downright unhappy, plan for such basic
prerequisites as health, education, associations, and public order so as to arrive at a state of happiness sooner rather than later (Meier 1999)?

Surprisingly, the most frequently used social indicator for happiness in a society is stability over a period of months or years. Some societies and communities are consistently happier than others (Veenhoven 1996). Research indicates that the Filipinos are happier than the Japanese or the Koreans, and the Icelanders come off happier than other European societies, even the wealthiest. We can only guess at what inexpensive inputs brought about this state of bliss.

An astonishingly promising effort to measure happiness was undertaken in concert with a scheduled transition -- the passing of apartheid in South Africa (Moller 1997). A picked team mounted a multidimensional measurement of changes in opinions, attitudes, and well-being during and after the event. The group and its sponsors were undertaking to guide the government through a period that had no precedents to help decision makers.

Happiness is an expression of subjective well-being and overall satisfaction with life. Serenity, which has been less frequently studied scientifically, is a special case that seems to be less aggressive in its demands, and ultimately more resource-conserving than happiness. All major religious systems sponsor communities to foster serene living, but the Buddhist and Hindu efforts are the largest. In these communities, people who report being very happy seem to be more active, and their mood is quite infectious.

The third measure of a good life, delight, is a "high" state that is sought by a significant fraction of a population. But achieving delight often has a downside later for the family and community, especially when it is achieved by engaging in infrequent activities.

Social well-being for individuals is genetically determined in part (Lykken 1995), perhaps even more so than intelligence. Thus it appears to be similar to educational achievement: learning and its benefits can be acquired more easily by those who are better endowed for intelligence at birth, although virtually all can achieve high levels of well-being with perseverance and discipline.
Recently accumulated findings are quite substantial (Diener et al. 1999). Exciting potentials for late-blooming societies and their constituent communities enable much more rapid advancement. They can aim directly at achieving several attractive flavors of happiness and forego a lengthy transition to a "tiger economy" in order to reach fully developed status (Meier 1997, 1999).

Simultaneously, as it will be argued in chapters 8 and 9, presently developed societies could improve their social well-being by dispensing with conspicuous consumption and directing more attention to the participation in happy "happenings", which becomes a new responsibility for managers.
Chapter Five Section Eleven

Planning with Indicators

Social Indicators Emerging from Urban Community

The metropolis of Seattle, Washington, has pushed the concept of superior, yet sustainable, quality of life farther than any other in the 1990s (Sustainable Seattle 1993).

A Civic Forum sponsored a group of fifteen people to undertake the identification and measurement of social indicators that focus upon the blemishes existing in an otherwise very high-quality urban life. This group was asked to suggest programs and projects that could be aimed at improvements and provide the appropriate assessments of progress.

The participants sensed that a self-satisfied public could easily allow Seattle's privileged ranking among cities to be undermined, leading to a sharp collapse. If quality of life is to be sustained, it must be defended and supported with a diligent search for evidence of decay and erosion, followed by prompt action.

The group identified thirty-seven "indicators" of change in the categories of environment, population and resources, economy, and culture and society.

Box 5-2 reflects evidence collected on seventeen of the indicators, for which the data were most readily available from sources within the region from slumps in its dominant industries -- forest products exporting and aeronautics -- but there have been no:

- destructive earthquakes
- great floods
- devastating fires
- disabling general strikes
- paralyzing urban riots
to interrupt its steady development
Box 5-2

Sustainability Indicators Selected Bottom-Up

Seattle’s List of Social Indicators for Sustainability

The group identified these factors as aspects of Seattle’s good quality of life. The list is slightly altered here for purposes of communicating to planners and designers.

1. Annual wild salmon are counted on their upstream runs to breeding areas in five adjacent small watersheds.

2. Air pollution and quality characteristics for dozens of districts.

3. Friendly pedestrian ways and streets that enhance livability.

4. Population growth can be embarrassingly rapid or too slow.

5. Residential water consumption can be reduced without noticeable quality decline or inconvenience.

6. Solid waste production can be reduced, and recycling effectiveness enhanced.

7. Vehicle miles and fuel consumption can both be decreased by 20 to 40 percent to reduce vulnerability to global shortages.

8. Renewable share of energy supply will increase the independence from a growing scarcity of nonrenewables.
The committee said that improvements in any, or all, of these dimensions would attract educated people to Seattle, who would bring their talents and savings along with them. That population inflow, more than anything else, would assure the city’s continued leadership in offering a superior quality of life. The city would also be better able to hold onto valuable organizations and their members, despite attractive offers from other cities.

The choices of social indicators reflect this good fortune. Other cities are haunted by the possibility of:
In order to prevent these eventualities, leading indicators for such disasters must be found and brought to light as warnings. Other cities will select new indicators, because a new global movement, led by people with environmental concerns, has a paradigm of its own that defines sins against sustainability. For example, they may have no single indicator available for the general health of the natural surroundings equivalent to the counts of the spawning salmon.

The urban ecological framework started in chapter 2 introduces other indicators and indexes of relatively universal value. The feature in this outline that is most applicable to the Seattle list is the symbol for harmony and health—the yin-yang balance insisted upon by the Chinese for guidance of families and government. Seattle’s approach fits a major part of its future, while the comprehensive ecosystem formulation offered in chapter 2 picks up too few of the year-to-year management phenomena to satisfy local decision makers. Planning for sustainability on a year-to-year basis requires an "outside-in" assessment along with this "inside-out" framework for keeping accounts.

**What Planners Get from Accounts**

Planners need to know what resources are likely to become scarce, so as to take action in time, and what others are becoming excessive, so as to prevent misuse.

To gather this information, they need to track inputs through the community, in both normal and critical times. What transactions admit these inputs into the community? The outputs are important in a different way, because they are dominated by exports of services and manufactured goods that are supposed to be exchanged for necessary inputs and to overcome accumulation of wastes that can pile up and eventually diminish life in the community. The following resources should be measured.
People Counts. The census is inadequate. It tends to count only those who normally sleep at an address. The daytime population is the figure most needed for planning. It can be approximated by making continuous passenger counts at the boundary markers and standardized by an occasional sample survey.

It would be advisable to break down population counts by:
- age
- gender
- social role
- resident-sojourner-visitor status
- knowledge repertoire (languages spoken, schooling, drivers' licenses
- state of health
- responsibilities for others

Some societies, such as the Germanic and the Nigerian, resent such data collection, deeming it an invasion of privacy. The various kinds of uncertainties involved suggest that people counts are reproducible within about 5 percent.

Energy. A community is a kind of heat engine, so energy must be conserved to keep it going. The community consumes food and fuels in order to produce action (in the Newtonian sense), almost all of it associated with people. On a caloric level the basic foods are three to ten times more precious than fuels, so separate accounts should be maintained. Electrical energy use can be shown in continuous accounts for all but the poorest and most chaotic communities. Due to variable solar contributions, line losses, evaporation, and spoilage, the total quantities of energy expended can be corroborated on a double-entry basis at about the 10 percent level.

Water. Water flows through the community should be moderated to within double or half the most comfortable level. Water flows provided by Nature are usually erratic.

In the relatively rare instances of flood and drought, when moderation through drainage and storage is needed, the community must be prepared to upgrade poor-quality water at considerable energy cost in order to meet
high-priority short-term human needs. Evaporation and transpiration by plants introduce much uncertainty, so the water accounts need only about 10 to 20 percent accuracy.

Each community is unique with respect to water supply and disposal, so the managers of water treatment facilities will have to decide what data they need in order to assure adequate service during foreseeable crises. Some crucial information will apply to the whole watershed, and data will often be collected outside the boundary of the community itself.

• Materials. Matter is conserved. In a practical sense it cannot be destroyed. Commodity markets will meet most planning needs without special efforts. Substitution of another commodity for a scarce material is very common, and the replacement can often be produced to order if energy supplies are adequate.

Flows of special materials, such as:
  • medicines
  • toxins
  • nutrients
  • drugs
may need separate accounting treatment.

• Time/ Life. Human time budgets are fuzzy because, when people pay attention, they frequently employ a multipurpose strategy for spending time efficiently.

Human time allocations are needed to understand the effects of congestion and friction upon the time left after work, sleep, care giving, and other high-priority activities. This residual is known as leisure, or discretionary time.

Self-reports on the use of time often conflict with third-party observations. Gershuny (1992) believes that we in the Western world are not really "running out of time," but Golden (1993), his admirer/critic, points out that Americans feel a critical shortage mainly because of the vastly increased participation of women in the organized labor force, which seldom as yet provides flexible time arrangements. Despite such perturbations, aggregate human time allocation can be estimated readily at the 3 percent
level, but the all-important free time only at about the 10 percent level. The small amount of time that remains for investments yielding improved quality of life depends upon the expected life cycle of humans and other key actors.

Allocation of more time to education and skill development can be afforded with increased life expectancy.

• Time/Space. The value of urban space depends most heavily upon time costs for passenger movement. Space accounting is done through land-use maps, which have been enhanced recently by computerized geographic information systems (GIS). The value of an urban plot depends heavily upon its time-distance from the center or subcenter of the city, and upon its neighboring land uses. In all but the poorest cities space accounting can be accurate at the 1 percent level.

• Transactions. The value of human activity is determined to a large extent by the number of transactions that are voluntarily completed per unit of time. In many ways this should be a better index of sustainable activity than one obtained from monetized accounts, because the share of transactions of different sizes (e.g., lapsed time for completion, information content, market value) will remain roughly constant when successive years are compared. The counting of transactions will increasingly be an outcome of the computerization of management.

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**Box 5-3**

**Partha Das Gupta’s Parallel Analysis**

After the uploading of this book onto the Internet had begun, another was published whose title appears to cover the same ground. How do they differ? Actually, they are complementary, with some overlap in the area of ecological accounting.

Partha Das Gupta, professor of economics at Cambridge University, has greatly expanded classical economics by
producing an elegant analysis under the title Human Well-being and the Natural Environment, but it has restricted its scope to classical economics. It neglects altogether the recent findings of behavioral scientists and their implications for economic engineering, because it still holds to a pre-1950’s view of information, so it cannot deal with urban futures. It does bring a lot of sense to the valuing of natural resources, goods, and services where political mistakes are rife.

Das Gupta sought rigor, and achieved it, whereas I have looked clumsily across many more subdivisions of knowledge for relevance to expected futures for both humans and ecosystems.

The capacity of an urban system for transactions of certain kinds will depend upon infrastructure planning. A great deal of experimentation is needed to put transaction accounts into a form that measures efficiency usefully.

Information transfer in the course of completing a transaction circuit is a prerequisite for any transaction, but because bit cost (for both stock and flow) is very rapidly declining, the average information flow will rise substantially.

Increases in transaction frequency are also a fair (understated) indicator of enhanced information flow, or richness of cultural activity, in a community.
Chapter Five Section Twelve

Happiness Deprivation

Life Satisfactions: Who Is Less than Happy and Why?

Once minimum adequate levels of living have been achieved, and relative peace is not threatened, the remaining reasons for unhappiness in a community are more subtle.

Sample surveys will reveal the most problematic components of the population. These groups need to be studied intensively. The issues often are as difficult to solve as violent crime, insecure social status, gender discrimination, racial and religious prejudice, homelessness, and the rise of privileged classes. The most truly unhappy community members typically make up 10 to 20 percent of the whole, with more women than men reporting unhappiness.

Happiness that is not shared throughout a community breeds stresses that threaten sustainability of school, organization and communities.

Perhaps this is why psychotherapists (in India) observe that it helps to practice laughing in public! The happiest people have high self-esteem, personal control, and optimism, and are extroverted (Myers and Diener 1997), but they often also feel guilty for being so lucky.

Those who are least happy feel self-destructive, depressed, and unable to contribute to community affairs; they may require treatment to treat their depression. The most sustainable communities are happier than the average, but the happiest communities may be lifted to their peak on a bubble that can burst, dropping the least autonomous individuals into despair and depression.

This is an area of concern in which research should pay off handsomely.

Once minimum adequate levels of living have been achieved, and relative peace is not threatened, the remaining reasons for unhappiness in a community are more subtle.
Sample surveys will reveal the most problematic components of the population. These groups need to be studied intensively. The issues often are as difficult to solve as violent crime, insecure social status, gender discrimination, racial and religious prejudice, homelessness, and the rise of privileged classes. The most truly unhappy community members typically make up 5 to 15 percent of the whole, with more women than men reporting unhappiness.

Happiness that is not shared throughout a community breeds stresses that threaten sustainability. Perhaps this is why psychotherapists observe that it helps to practice laughing in public! The happiest people have high self-esteem, personal control, and optimism, and are extroverted (Myers and Diener 1997), but they often also feel guilty for being so lucky.

Those who are least happy feel self-destructive, depressed, and unable to contribute to community affairs; they may require medication to treat their depression. Policies will be discussed in the final chapter, because they have important long range consequences. The most sustainable communities are happier than the average, but the happiest communities may be lifted to their peak on a bubble that can burst, dropping the least autonomous into an abyss of depression, which then requires time and attention for recovery.
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Gottmann, Jean, 1983. The Coming of the Transactional City. College Park: Institute of Urban Studies, University of Maryland,.


Monticello, Ill.: Vance Bibliographies, no. 259, June.


Sustainable Seattle 1993: "Indicators of Sustainable Community." Seattle.

