"Innovation and Knowledge-Sharing Across Public and Private Sectors: The U.S.-Brazil Sustainability Consortium"

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The shift to a sustainable future depends on innovation and knowledge-sharing across public and private sectors at various levels, from global to local. This chapter reviews the U.S.-Brazil Sustainability Consortium as a case-study for innovation and knowledge-sharing, and for partnering among public and private sectors for innovation and knowledge-sharing to implement sustainability as pathway for economic growth. It explores processes, tools, and techniques evolved by the consortium for global, regional and local commercialization of sustainable technologies.

Sustainability, Systems, and Innovation

Through the agricultural, industrial and information ages, society has increasingly failed to integrate innovations into contextual systems. Most recently, we embraced technology, globalization, and living beyond resource limits and regeneration rates. This resulted in environmental degradation, gross disparities in wealth distribution, loss of cultural identity, and other problems we now understand as symptoms of a meta-crisis (Capra, 1984) of disconnect from context and false belief that we can ignore natural laws and local limits (Quinn, 1995). Sustainability requires that we embrace innovation, systems-thinking, and sustainable technologies, networks and communities. We must think integratively and with cognizance of systems dynamics. We must be committed to the health and productivity of diverse systems (physical, ecological, and human) and manage, plan and design people-environment relationships and interventions that address today's need, sustain the ability to address future needs, and help regenerate system capacity. We must apply what the knowledge society understands through innovation that integrates decisions to sustain resources. We must understand that systems are integrated wholes (things and relationships), that function through dynamic interrelationships and exhibit properties independent of their parts. As we intervene in these systems to address our short- and long-term needs, we must understand that the degree to which we integrate our decisions into existing systems affects system health, productivity, and ability to sustain itself and the resources upon which we depend (Motloch 2001). Sustainability requires that we integrate our decisions into regenerative systems and life-cycle flows in ways that sustain a positive ecobalance where future productive potential equals or exceeds present potential.

Technology, Business, and Innovation in the Knowledge Society

Many people believe information technology draws the world together into a global community (based on the distance-canceling powers of internet and web-based communication), enabling access to global talent, technology, capital and know-how and promoting increased trade and cultural interaction. Others are concerned that despite their positive outcomes to some people, the industrial revolution and more recently the knowledge revolution and scientific and technical advances have increased the economic welfare, health, education and general living standards of only a relatively small fraction of global population to record levels. (Gibson, s.d.) [1]

[1] Gibson, D. V. et al.; "Incubating and Networking Technology Commercialization Centers among Emerging, Developing and Mature Technopoleis Worldwide", IC², The University of Texas and Austin, s.d.

Techno-Apartheid In The Business Knowledge Society: Despite its empowering potential, Internet access is limited and exclusionary. According to the UNDP's Human Development Report of 1999, geographical barriers may have come down for communications, but a new barrier has emerged - the so called global *techno-apartheid*, where:

- Southeast Asia, with 23% of global population, has less than 1% of Internet users;
- 30% of Internet users in the world in 1998 had at least one university degree;
- Buying a computer would cost an average Bangladesh citizen more than 8 years of salary, while it costs the average US citizen less than a month's salary;
- Women comprise only 17% of Internet users in Japan and 7% in China;
- The majority of Internet users in China and the UK are younger than 30's;
- English language prevails in 80% of Webpages, but is spoken by only one person in 10 globally.

Information technology (IT) concentrates innovation diffusion in receiving countries, more educated social layers, and people with globalized lifestyles. While IT can accelerate knowledge-based industry growth, as it has for software companies in Ireland and computer services in India, Internet access is concentrated in a minority in the richest countries: OECD countries, with 19% of world population, comprise 91% of Internet users. Table 1 shows regional concentration of Internet access

While geographic proximity is becoming less important for business in the knowledge-based society due to information network infrastructure development, the sustainability of economic and social assets that may be generated locally depends on a stable network of local social relations and sense of community ownership. Stable social networks depend on symmetric flows of information, capital, costs and benefits; and this symmetry brings to the stage complex diverse systems of values. The global/local relationship is becoming a key issue in political agenda as reaction against globalization of markets directed to international organizations (WTO, IMF World Bank) reaches the streets in Seattle, Washington and Prague. Increasingly, issues of global technology transfer, innovation and commercialization must consider the social, economic and environmental aspects of sustainability.

Increasing Access to Technology in the Business Knowledge Society: Advantages of IT and the Internet include access to large amounts of information rapidly from websites or discussion groups. Its disadvantages include difficulty in determining information legitimacy and quality. Also, until recently, these technologies have been available only to the well educated, and people of high incomes in developed and developing nations. The challenge now is to create ways for all people to benefit from technological advancements. Examples of low-income groups accomplishing this include the early 1990s introduction of cell phones in rural villages of India to help local entrepreneurs and residents; and current successful introduction of Internet services in previously excluded communities and parts of the world. For example, cybercafes and kiosks throughout Mexico are places for people to interact. The Monterrey Institute of Technological and Higher Education (ITESM) is implementing its Virtual University (VU), an entire educational system that provides education in rural communities and low-income urban neighborhoods. The VU focuses on basic education and job skill development to people in Mexico, and Hispanic populations in other Latin American countries. "These communication links have dramatically altered the way villages function and how they are connected to the rest of the …world." (Prahalad and Hart 2002, p. 11)

Post-apartheid Business Innovation in Emergent Markets: In *The Fortune at the Bottom of the Pyramid*, Prahalad and Hart (2002) maintain that emergent markets (former Soviet Union, China, India, Latin America) represent a great opportunity for business and innovation. They note these emerging markets are not the traditional middle-income class groups targeted by large corporations in the 1990s, but the poor in nations that opened their doors to free enterprise. If this is the case, "…companies will be forced to transform their understanding of scale, from a "bigger is better" ideal to an ideal of highly distributed small-scale operations married to world-scale capabilities." (p. 2). Whether Prahalad and Hart's assumptions are correct or not, civil society, government, and private enterprise are becoming aware that living conditions for the majority must improve if greater social and environmental conflict are to be avoided. Those who realize that improvement must occur also recognize it must be done collaboratively. "Unless the private-public-union-scientific partnership takes shape and form and co-operate towards a common vision where we wish to be, there is little prospect that society as a whole can move forward…" (Pauli 1998, p. 198). With the growing role of collaboration, NGOs and citizen organizations around the world have become important proponents of national and international alliances to address local conflicts within a global context.

Partnering for Innovation

Partnering is a strategy whereby organizations around the world dealing with similar challenges take collective action and systemically organization to efficiently use resources and fulfill common interests. Groups of stakeholders join effort toward common goals. Issues including scarcity of resources, maximization of potentials, and good use of expertise motivate partnerships to address common challenges (Dean, Murk, Del Prete, 2000). Individuals and groups work together to create partnerships with a life and culture of their own. As partnerships evolve, stakeholders develop social and psychological contracts to guide their work and improve the services and products they deliver.

In developed and developing nations, partnerships have become an important way to address social and environmental challenges. The not-for-profit sector has taken the lead organizing and implementing collaborative initiatives for the common good. In recent years, and with support of international organizations, partnerships are being formed with local government, private companies, and NGOs. In Mexico, for example, the World Bank, United Nations, Nature Conservancy, Habitat for Humanity, Kellogg Foundation, Walton Family Foundation, and others have partnered with communities, governments, and NGOs to alleviate poverty, introduce public services, undertake productive projects, provide housing, and so on. In 2002, ITESM collaborated with local partners in Oaxaca, Mexico, federal agencies and international donors such as the Kellog Foundation to establish community learning centers. These centers are based on IT targeting of ethnic groups in the state by offering bilingual reading and writing programs to children and vocational training to youth. Similarly, in 1998, the ITESM (Monterrey campus) schools of architecture and civil engineering implemented 10X10 (Ten Houses for Ten Families) a housing and community program in low-income communities of urban Monterrey. 10x10 was developed and implemented through a partnership between ITESM, local NGOs, the municipal government, and a private enterprise. In these partnerships diverse groups pursue common interests.

<u>Business Partnering for Innovation</u>: Business partnering to address common agenda is a well established strategy. In the past, these partnerships have been mostly used to share information and expertise, reduce production costs, develop products, and so on. Examples of international partnerships include the one by Netscape and America-on-Line to increase cyber links and improve Internet connections; and by IBM, Apple Computer, and Motorola to develop an operating system and microprocessor for a new generation of computers.

<u>Local-Global Partnering as Strategy for Innovation</u>: Innovation can build upon the global trend of creating local entrepreneurships between large corporations and local residents. Bu global

partnering, local companies can address the needs of the poor by facilitating employment opportunities and financial and technical support needed by low-income groups to undertake innovative ideas that emerge from their own context. These local-global partnerships can support local groups and pursue vernacular technologies that have a positive impact in the lives of low-income people who for the most part do not now have access to formal financial and technical mechanisms available to other income groups.

Challenges for Innovation: To achieve IT potential, fight concentration distortion and improve access to IT, the UNDP Human Development Report proposes seven actions:

- MORE CONNECTION – with further development on telecommunication and IT infrastructure;
- MORE COMMUNITY – enabling access to groups, not only individuals;
- MORE CAPACITY – building human qualification for the knowledge society;
- MORE CONTENT – increasing local perspectives into the Web;
- MORE CREATIVITY – adapting technology to local opportunities and necessities;
- MORE COLLABORATION – developing IT to address local and global communities goals;
- MORE MONEY – finding innovative pathways to finance the knowledge society.

In addressing IT challenges, we should remember that technology is not inherently good, bad, or neutral.[2] Its effect occurs through complex material and social relations and it generates known and unknown consequences over a very long time span.

Unfortunately, as technology transfers modernization (old name for innovation) and globalization it can cause or aggravate local social problems.[3] Also, in most countries, innovation favors public policies regarding development. As such, institutional, political and legal environments with technology innovation policies are deeply connected with the whole social structure. “States with transformative aspirations are, almost by definition, looking for ways to participate in ‘leading’ sectors and shed ‘lagging’ ones. [...] These states are also hoping to generate the occupational and social structures associated with ‘high-technology industry.’ They are hoping to generate a multidimensional conspiracy in favor of development.” (Evans, 1995, p.10) As a result, most innovation policies are characterized by a:

- Search for creative shortcuts to produce superior outcomes (mostly profits) than those perceived by conventional productive activities already established;
- Focus on global market and global social class with international demands and tastes;
- Heavy investment in research and development, mainly with public funds, in highly competitive market “niches” in edge technologies, especially IT.

Innovation in the Technology Sector: Innovative entrepreneurs in the technology sector search for innovations that could produce a higher growth rate than normal under traditional production cycles and a *scale jump* in business and revenues. Classical economic theory defines two necessary conditions for gains in production scale: technological innovation and new social production relations (and, of course, consumption). Those conditions are not independent from each other - for each social arrangement there is a set of technologies that apply.

[2] This affirmation is know as the “First Law of Kransberg”, from the technology historiscist Melvin Kranzberg, cited in Castells, 1999.

[3] For an comprehensive study of undesired innovation outcomes where social, environmental and economic relations are considered, see Poungsomlee and Ross, 1992. For a collection of success and not so successful cases of local social capital build-up based on information technology innovations in Brazil, India and Korea see Evans, 1995.

New successful technologies that produce scalar growth – innovations –imply new social arrangements. For example, Internet-based e-commerce depends on connection to growing numbers of potential buyers and suppliers with network access capabilities. This has consequences in the educational sector and interpersonal relations; as bridging the "digital divide" strongly interferes with deeply rooted social communication protocols, a foundation of every society. Progressive public policies usually focus on the first condition, and the second is a consequence. This occurs because these policies give more control to the state (investment in concentrated areas) and assure support from the private sector interested in high-tech markets; but does not invest adequate political effort and deep commitment (from state structure and funds) to address the much more complex issues related to social structure.

Sustainability in the Knowledge Society

Since the late 1980s, developed nations have made important progress towards understanding and implementing sustainable principles for development. Nevertheless, this understanding and application is only a small portion of what needs to be done globally. It is estimated that the two thirds of global population living in developing countries continues to consume products and services in resource intensive and excessively polluting ways. In many cases, these products and services have been brought into local markets at the expense of cultural values and lifestyles. Until recently, it was thought that only developed nations could afford the luxury of thinking and acting sustainably. Now we understand that sustainable development is urgently needed by, and can be available to, all. The world needs alternatives that satisfy everyone's basic need for food, water, energy, health, and housing; in ways that enhance local dynamics and respect nature.

<u>Sustainability Through Diversity in the Knowledge Society</u>: Sustainable solutions are finely-tuned to regional and local conditions; and sustainability in the knowledge society must address ecological and cultural diversity. Ecologically, the world consists of at least 14 terrestrial biomes, 7 freshwater biomes, and 5 marine biomes; and at least 867 terrestrial ecoregions and hundreds more marine and fresh water ecoregions (National Geographic Society, 2000). Each ecoregion has its climate, physical features, and species that must be respected in the way we make decisions. In the past, limited technologies meant that vernacular construction was place-based. Construction in the mountains differed from that in the lowlands as each responded to temperature, humidity, and so on. Earth-base materials were widely used in dry and temperate regions, but not in the rainforest. Regions also differ culturally, producing a rich global cultural palette. Historically, natural context influenced construction systems and culture influenced form and function (Rapoport, 1969).

Social norms and interactions also influence construction's social role. For example, Amish home building in North America is a social activity that keeps family members together and strengthens community ties. In urban neighborhoods of Latin America, building is an important component of community life. Nature and culture go hand in hand to produce sustainable environments that nurture individuals and prepare them to become responsible community members. These processes generate alternatives that are environmentally healthy, socially responsible, and economically viable. Generally, innovation to increase sustainability seeks to answer three questions: "How can we learn from distant neighbors that are culturally different, but share ecoregional characteristics?; How can technology help us learn from distant neighbors that live in similar ecoregions?; and "How can we realize the potential of the Internet's increased information-flow to disseminate information about sustainability, shared ecoregional and cultural challenges, and locally sustainable solutions?"

Partnering for Sustainable Development

This section reviews global partnerships for sustainable initiatives, the role that technology plays in creating these partnerships, and the potential of emerging market to establish partnerships for sustainable development. It presents the anatomy of an international partnership; the stages, principles, and conditions for implementation of a global partnership; and conclusions about how an international and collaborative partnership may help link people, places, and ideas for innovation. It uses personal experience and state-of-the-art on collaborative partnerships as main references.

<u>Global Partnerships for Increasing Sustainability</u>: Since the 1990s there is a growing interest in sustainability; and both rich and poor societal groups feel the need to integrate sustainable principles in current ways of life. Environmental degradation, unequal distribution of wealth, and loss of cultural values are making us question our current ways of life and their implication to our specie's survival. Historically, around the world each culture evolved healthy, regenerative, supportive lifestyles. With globalization we ceased to apply this knowledge. Reapplying it can be important for ourselves and can inform other cultures with similar life patterns and challenges.

Global partnering for IT development over the past two decades allowed the business sector to increase its profits and markets. Corporations benefited from the Internet, satellite broadcasting, and broadband IT systems. It is now imperative that we use IT to benefit individuals and communities around the world by raising awareness of local sustainable solutions. Global collaborative networks can raise awareness by learning from other cultures how to address local challenges and create new ideas, products, and services without repeating mistakes or replicating experiments. As stated by Gunter Pauli, "human beings can learn from nature, not by striving to be the strongest but by seeking collaboration across races and cultures, respecting the difference, and recognizing that only by co-operation will they succeed in converting limited resources into and abundance for all." (1998, p 26)

<u>Innovation in IT Systems as Sustainability Design Problem</u>: Given the intricate set of economic and social relations involved, innovation in IT systems can be seen as a complex design problem, where new technology products and processes can cause or aggravate problems it tries to address. Considering the seven proposed actions as design goals for innovation, one can define at least two sets of design principles. The first set contemplates the sustainability of social relations; and reassesses global networks and issues of technology innovation, transfer and commercialization in consideration of social, economic and environmental impacts at the local level. The second set focuses on sustainability of network infrastructure. For a knowledge community whose information infrastructure relies on a global physical network, the World Wide Web, sustainability means the ability to sustain the flow of information in the network. This was central to the first studies and blueprints, by the RAND Corporation in the 50's and 60's [4], of what we now call the Internet. The challenge was to figure out what sort of connected communication system could keep working after major destruction caused by military attack, most likely a Soviet nuclear strike. For a knowledge society, basic infrastructure network resilience was seen as necessary for continuous flow of information, even contradictory and ideologically conflicting information, to keep going under any kind of attack: physical, virtual or ideological.

<u>Commitment and Symmetry: Building Sustainable Communities</u>: The local/global relationship is becoming a key issue in the political agenda. According to Manuel Castells, in the new network

[4] For a more appropriate report about the hardware and software evolution since RAND Corporation and ARPA in the 60's and 70's towards the present-day modems and TCP/IP protocols, see Horzepa, 1989.

society a "structural schizophrenia" emerges from the conflict between two different spatial logics: human experience that still relates to the "local", and society's dominant functions and power organized in global flows of information, capital and power. (Castells, 1999) This local/global relationship requires that we build sustainable communities at both the local and global level. Although "community" traditionally implies some sense of "local", emergence and evolution of the IT interconnected world means we may have begun to experience "global community", even when we are thousand of miles apart.

This begs the question … "what is community?" For some, community means devoting time to common issues: neighborhoods, support groups, local politics, and so on. Social bonding is probably the most valuable asset societies have, and one that is doubtless crucial to our survival as a species. This "sense of community" brings us feelings of continuity, safety, familiarity and a framework of commonly shared values to orient our actions, perceptions and reasons to live. Sustainable communities are those groups of people who sustain themselves and their relations without impairing possibilities of future generations to sustain themselves. Community sustainability accrues from healthy people-people and people-environment relationships (Motloch, 2001, p.257).

Community involvement presupposes some degree of commitment. A community relies on its members to keep on existing, and that implies voluntary individual commitment to the community. Of course, in a free and democratic society, one will only join a community if she or he feels this is worthy. Individual freedom to choose community participation implies symmetrical relationships within members. Without symmetry, true community commitment is not sustainable.

Symmetry, as addressed here, does not mean uniformity and boring stability. As a design criteria for innovative IT systems, symmetry means using information to balance, in a given time span, all the relations each member has within a community, in particular those related to the:

- Breadth, integratedness and scale (spatial and temporal) through which the community makes decisions;
- Flow of information in the community, and degree to which this flow pursues the regenerative life-cycle flows of resources;
- Extent of involvement of members of the community in decisions that affect their future and the future availability of resources.

Some examples of symmetry are the design of interactive voting systems, allowing voters to receive quick feedback on consequences of their choices on local or regional issues. Applied to innovation in industrial production, the symmetry principle would enable life-cycle design of products and processes, and a commitment to industrial ecology (Fisk, 2000).

Commitment and symmetrical relations are not only important relations in community sustainability, but are fundamental when we go beyond the everyday contacts we have in our neighborhood and start to think about constructing sustainable global communities. This could include the design of well-informed global stock markets, where traded bonds reflect not only financial but also environmental and social bottom lines, including the effects of investment on country economies. Another example could be information systems directed to assessing and calculating the value of trading carbon emissions at a global scale in real time, giving a new push for the Kyoto Protocol and Clean Development Mechanism.

Network Structure and Information-Flow

Many global infrastructure networks show centralized structural patterns. Continental petrol and gas distribution networks and national electricity systems (e.g., Brazil), have centralized patterns. This type of pattern appears to be associated with expanding systems, where economic efficiency forces the network to develop a *treelike* pattern, with few cycles and a relatively small number of prominent central nodes (Ramina, 2000). Although cheap to construct and easy to control, these centralized networks are vulnerable due to their limited number of nodes and paths of flow. On the other hand, later stage mature networks resemble "random networks", with higher connectivity and denser connections among nodes, and more cycles that distribute risk among a larger number of elements. The sustainability of mature networks seems to be associated with rich connectivity and structural complexity, rather than with the rationality of control and dominance.

Regarding one of the proposed actions above – MORE MONEY – Web infrastructure construction is expensive in early stages of development, given the size of investments in IT innovations needed for its implementation and relatively small number of users ready to connect, specially in developing countries. This may be the cause of the Web's present centralization and small number of major hubs. But at the same time, this pattern is the footprint of a strong monopolistic environment.

In 1964 the optimal structure of the Internet was analyzed. From three possible network architectures – centralized, decentralized and distributed (figure 1) – both centralized and decentralized structures that dominated communications systems of the time were demonstrated to be too vulnerable. The natural conclusion that the Internet should be designed as a mesh-like architecture was defeated by the military and AT&T, the communication monopoly of that time (Barabási, 2002).

<u>Current Web Network</u>: It is estimated that, starting from any page one can currently reach only about 24 percent of the billion or so documents on the Web. The rest are invisible to us, unreachable by surfing. It is estimated also that about a quarter of all Web documents lie in *islands*, isolated groups of interlinked pages unreachable from the *central core*, the home of all major websites from Yahoo! to CNN.com. In a recent research report about the topology of the Web and its implications, Albert-Lázló Barabási remarks that there is a ..... *complete* absence of democracy, fairness, and egalitarian values on the Web … the topology of the Web prevents us from seeing anything but a mere handful of the billion documents. [...]the architecture of the World Wide Web is dominated by a few very highly connected nodes, or *hubs*. [...] The hubs are the strongest argument against the utopian vision of an egalitarian cyberspace (2002, p. 56-8).

<u>Increasing Connectivity and Symmetry for Network and Community Sustainability</u>: Applying connectivity as a design principle for innovation in the World Wide Web would increase the number of possible connections among members of a global community. Increasing the number of channels, however, does not necessarily lead to less vulnerability unless connections are distributed among a growing number of nodes, making the whole network a dense mesh. Such design could give strong credit to technological solutions like Internet radio, "echo-links", "packet-radio" and a multitude of interconnected technologies, some concentrated, some distributed (Ramina, 1993).

Increasing connectivity implies also building local capacity and matching IT development to local conditions and needs. Applying both the connectivity and the symmetry principles together would result in a careful balance between local and external production of contents, addressing some of the actions proposed in the UNDP Human Development Report of 1999.

US-Brazil Sustainability Consortium: Case-study in Leading Society to a Sustainable Future

There is a major need to enhance global information-flow and networking for sustainability, and to build regional partnerships that translate global knowledge about sustainability into regional agenda that lead society to a sustainable future through value-adding economic development. These partnerships need to integrate into, and enhance, the sustainability information-flow network, while serving as information clearinghouses with agenda that advance and communicate knowledge of regional sustainability indicators, baselines, and benchmarks. They need to interconnect to form a global sustainability library for sharing information about translating the global need for sustainability into regional agenda, identifying value-adding ways to operate sustainably in specific regions, and connecting local and regional needs with global funding opportunities to address these needs.

<u>The Land Design Institute</u>: Ball State University's Land Design Institute (LDI) seeks to increase the flow of information that connects people into the dynamics of complex local and regional systems, and to facilitate behaviors that produce sustainable decisions and trigger "streams" of sustainable downstream decisions. By these and other means, LDI seeks to help lead society to a sustainable future (Motloch 2003).

Global Networking of Regional Centers for Enhanced Sustainability: The LDI envisions a global sustainability network of biome or eco-regional based centers and landlabs that enhance information-flow about sustainability and trigger behavioral change (Figure 2). It sees these as regional education, research, outreach and demonstration centers that 1) connect people to sustainable relationships with local resources and cycles, 2) translate national and global desire for sustainability into regional agenda, 3) engage in partnering with other network members, and 4) integrate regional agenda into a global network of sustainability information-flow. The LDI is currently facilitating this global network of centers and partners and sharing knowledge with others in this network to trigger change.

Through partnering, LDI seeks to build symmetrical information-flow about sustainability, including symmetry in scale, where global sustainability is achieved through local decisions, and global potential applied to address social, economic, and environmental impacts at regional and local scales. It includes symmetry in its vision of sustainability, embracing and balancing the developed world's environmental bias in sustainability focus with the developing world's greater social and economic foci.

Resource-balancing Land Use, Management, Planning and Design: Through this global network of regional centers, the LDI pursues a vision of life-cycle based and resource-balancing land use, management, planning, and design. In this approach, decisions help sustain and regenerate regional and local resource-bases, so that downstream capacity (after decisions are implemented) equals or exceeds capacity prior to implementing decisions, Figure 3.

Sustainability via Integration with Complex Systems: The LDI pursues sustainability through land management, planning, and design that integrate into complex regional and local contextual systems (physical, biological, cultural, economic) and life cycle flows (energy, water, and so on).

Value-Addition through Levels: The LDI pursues sustainability via value-adding solutions at increasing levels of integration of decisions into the dynamics of complex systems. It seeks partnerships to identify appropriate levels of integration based on the dynamics of the systems into which decisions must integrate, the information available to inform decisions, management structure sophistication, management resources available, and desired level of value to be added (Figure 4).

Ecobalance Partnering: The LDI promotes international partnering to share information and identify solutions that apply global and local knowledge to address needs through decisions that integrate into local and regional life cycle flows and promote ecobalance. The LDI partners with others to support regions and locales in environmentally responsible, socially equitable, and economically viable ways.

Innovation-Intervention Methods: The LDI embraces innovation-intervention processes (Hatchuel, Agrell, van Gigch, 1987) of management science, that bring people with different expertise into collective visioning. Participants transfer control of decisions within their expertise to the collaborative group. Innovation-intervention models promote innovation by helping the group achieve a collective vision that sees beyond the paradigmatic boundaries of the participating disciplines.

Pathway to Technology Commercialization in Complex Systems: The LDI is facilitating a network of international sustainability consortia using innovation-intervention processes to discover complexity, potential, and needs. This network identifies and integrates value-adding sustainable innovations into complex local and regional systems; and promotes commercialization of sustainable technologies. It identifies benchmark projects, such as Figure 5, that integrate local value-adding, waste-recovering, integrative-technology projects into a distributed energy network. Typical projects add value to waste, seek ecobalance, create opportunities for new markets, and enhance environmental quality.

Multi-sector Partnering to Leverage Funding: The LDI partners with universities, government, industry and other sectors to access and integrate academic and project funding streams into strategies for program seeding, short- and long- term implementation, and program sustenance.

<u>Sustainability Consortium Model</u>: The need for enhanced understanding of, and information-flow about, sustainability has led to the LDI *Vision* of a global network of sustainability consortia -- as inter-regional partnerships and as a global network of sustainability change agents. It sees this global network pursuing the *Goal* of leading society to a sustainable future through *Innovation* that facilitates change. It envisions this network operating through *Partnerships* of diverse disciplines and sectors with the breadth of awareness necessary to identify and embrace *Integration* to achieve sustainability through value-adding processes and technologies that interconnect solutions with complex contextual systems.

The LDI is partnering to build this network of regional partners, and develop programs that facilitate their success. This network began with the US-Brazil Sustainability Consortium (May 2002) and is expanding with the North American Sustainability, Housing, and Community Consortium and envisioned consortia with other Latin American and global partners. U.S. partners of this network, the Land Design Institute (John Motloch, Director), the Center for Maximum Potential Building Systems (CMPBS; Pliny Fisk, Co-Director) and the IC^2 Institute at the University of Texas at Austin (David Gibson, Program Director), seek to enhance information-flow about sustainability and to trigger change.

<u>Process of Building Sustainability Consortium Partnerships</u>: Building inter-regional sustainability consortium is seen by LDI as a four stage process (Figure 6).

Consortium Emergence: The LDI facilitates inter-national sustainability consortium emergence by identifying and convening multi-sector partners who seek societal change to sustainability. This phase, usually funded by the partnering institutions, brings partners together for a short, intense *Visioning Workshop* that includes a search for fit among partners, collective visioning, conceptualization of consortium agenda and potential projects, and commitments to refine and build from this initial agenda and project list.

Consortium Seeding: Stage 2 includes institutional *Support-Building* for formal agreements, institutional commitment to partner on projects, and seed funding for Stage 2 *International Institutional and Project Visits*, where the team visits partnering institutions, sustainability initiatives, and benchmark projects; and explores local opportunities to benefit from inter-national partnering. The team conceptualizes sustainability curricula and curricula fit in each institution, and meets with institutional administrators to gain commitment. This phase usually includes academic funding, signing formal inter-agency agreements, refining place-based strategies for leading regions to sustainability, awareness-building about benchmark and urgently needed projects, and prioritizing projects.

Implementation Start-Up: Stage 3, Implementation Start-up, usually implements a multi-year *Initial Academic and Project Funding* program and agenda for short-term regional projects. Successful completion of a number of these short-term projects builds the track record of partnering among consortium members that is essential for success in the final sustained implementation phase of the consortium.

Sustained Implementation: Sustained Implementation implements a program of *Long-term Academic and Project Funding* of projects to lead society to a sustainable future and sustain the consortium. It includes institutionalizing the consortium through agency, foundation, project, or other funding.

<u>US-Brazil Sustainability Consortium Process and Evolution</u>: The USBSC, pilot project for this global network of sustainability consortia, started with the desire to do projects together; and LDI identification of the US-Brazil Consortium Program of the U.S. (FIPSE) and Brazilian (CAPES) Departments of Education as funding vehicle to bring partners together on a regular basis for a period of four years.

Consortium Emergence: The USBSC emerged in a two-day May 2002 Visioning Workshop including John Motloch (Director, LDI), Rodolpho Ramina (TECPAR), Pliny Fisk (Co-director, CMPBS), Ramiro Wahrhaftig (Secretary of Technology, Parana, Brazil), Dave Ferguson (Director, Center for Design Media, BSU), and Pedro Pacheco (Doctoral Student, BSU). Partners identified their organization's goals and interests in relation to the consortium, resources the organization brought to the team, supports needed, potential constraints to their participation, and their view of consortium potential. Shared views and values emerged. Partners committed to 1) facilitate a societal paradigm shift by integrating sustainability into society, 2) foster sustainability education at all societal levels and in diverse audiences, 3) pursue projects as vehicles for education, research, outreach, and demonstration, 4) encourage industry-government-education partnerships, 5) pursue multi-scale projects, resource-balancing, and resource-management, 6) embrace educational and project initiatives in energy systems, green-building, and resource-balancing, 7) implement eco-balancing to promote place-based decisions and community-building, and 8) pursue parallel academic and project funding to include initial internal consortium seed funding, academic and short-project start-up funding, and major project sustained funding, Figure 7. This parallel phased strategy sought to initiate and sustain an integrated academic-project pathway to promote societal change to sustainability, innovation, and green technology commercialization. The FIPSE-CAPES program was targeted for primary start-up funding; and the proposal's approach and sustainability curricula were conceptualized. An initial list of seven potential sustainability projects of common interest was identified. This workshop, internally funded by each agency, was held at CMPBS to facilitate participation of this not-for-profit.

A consortium structure was identified (Figure 8), with consortium partners comprising a council that manages overall program, consortium projects, and pool of experts. Partners identify projects to be managed by the appropriate partner, and staffed from the pool. Projects build-in funding for staff and project coordination. The Council oversees overall consortium agenda and project coordination.

Consortium Seeding: The U.S.-Brazil Sustainability Consortium was seeded in Summer & Fall 2002 including a 10-day visit of U.S. partners to Brazil. The team met with Brazil partner organizations, tested distance education delivery compatibilities, upgraded these compatibilities, visited benchmark projects, favelas, and computer game-development incubators, and identified potential projects (six sustainability knowledge-building projects, three sustainability educational game projects, one energy production demonstration project, two green-building demonstration projects, three community capacity-building sustainability projects, eight sustainability visualization projects). In this phase, internal institutional and agency funding included funds for participation of the not-for-profit partner.

Implementation Start-Up: The USBSC is now in the implementation start-up phase. In 2003, the consortium received four-year consortium funding from FIPSE (US Department of Education) and CAPES (Brazil Department of Education).

Sustained Implementation: This consortium is also developing its program of long-term sustainability projects that can lead society to a sustainable future while sustaining the consortium. This includes major value-adding integrative technology programs, distributed energy projects, resource-balancing programs, and consortium institutionalization through major project, agency, and international foundation funding. Consortium members are now partnering to pursue project funding through International, U.S., and Brazilian sources of funding.

<u>USBSC Proposals to Help Accelerate Sustainable-Technology Based Economic Development</u>: The consortium is seeking funding to accelerate sustainable economical development, including funding to develop the sustainable development dimension of the IC^2's Green Wetware (Skill) for Global Technology Centers (TCCs) proposal. In this proposal, IC^2 seeks to accelerate technology-based economic development through globally-networked TCCs that foster growth of targeted small and medium sized enterprises (Gibson et. al., pd.)

The consortium has also proposed four-day "Toward Sustainable Development Workshops", where consortium members, IC^2 Fellows from each partnering region, and IC^2 staff work together to translate the concept of sustainable development into an Action Agenda, specific programs, and action items that IC^2 can pursue to effectively realize the sustainable development dimension of its mission.

<u>US-Brazil Sustainability Consortium Tools and Techniques</u>: The USBSC embraces innovative tools and techniques to address issues and facilitate societal shifts to sustainability. These include networking and community-building tools and techniques that promote Ramina's (2003) symmetric flows of information, capital, costs and benefits to sustain a stable network of local social relations, sense of community ownership, and system complexity; and address his challenge to balance global information, capital and power flows with the innate need of people to connect to the immediate world around them.

The consortium is pursuing funding to evolve and apply ecological footprinting and resource-balancing tools and techniques to make land use and master planning decisions based on Fisk and Armistad's (2003) Life Cycle Space™, regional resource dependencies, network analyses, and decisions that trigger commercialization of value-adding sustainable technologies. The USBSC is pursuing tools and techniques to address the challenge to apply industrial ecology concepts to physical planning and design, to rethink land uses based on resource-balancing, and to increase efficiency through flexible manufacturing methods designed for renewable processes.

The consortium seeks project funding to develop and apply tools and techniques that implement interagency collaboration models to create, evolve, and maintain linkages of people, places, and ideas for innovation (Pedro Pacheco, 2003). These activities benefit from past experiences of consortium partners in Latin America; and enable consortium partners from different countries to facilitate innovation and sustainability in community development through interagency collaboration.

The USBCS embraces techniques, models and tools that interconnect academic and project funding to make regionally- and locally- appropriate decisions that connect people, ideas, and resources. It implements models to enhance sustainability knowledge-flow as pathway to economic development, and tools and techniques for knowledge-sharing as pathway to regional and global commercialization of sustainable technologies. It embraces a wide range of hands-on and virtual tools and techniques -- from systems dynamic modeling to games -- that connect diverse audiences to regionally-appropriate, socially equitable, and economically viable place- and resource- based decisions.

Techniques and Models

The USBSC is applying innovative techniques and models to make regionally and locally appropriate decisions that connect people into the dynamics of complex local and regional systems, facilitate behaviors that produce sustainable decisions, trigger "streams" of sustainable downstream decisions, and help lead society and local communities to a sustainable future. To do so the USBSC is building international collaborative partnerships among diverse populations.

International Collaborative Partnerships: Cervero (1988) identified different types of partnerships used by organizations to work together including monopoly, parallelism, competition, cooperation, coordination, and collaboration. These differ from one another based on the degree of interdependence among organizations. Collaboration is the most interdependent and widely used by organizations dealing with social and environmental programs. When partners collaborate, a sense of authorship develops around programs and group initiatives. Collaboration is embraced herein as the preferred partnership type, as is Donaldson and Kozol (1999) model for evolution in collaborative partnerships. This model's four components -- emergence, evolution, implementation and transformation – interact in a cyclical way (Figure 9). According to this model, collaborative initiatives progress through the first three in order. Transformation occurs throughout the relationship as partners assess their performance. In the emergence stage partners are selected, the decision to collaborate is established, and a common agenda is defined. In many cases, partners are selected based on a commonality of interests, rapport developed between individuals, and compatibility of organizational values and principles (Kanter, 1994). The evolution stage involves establishing the direction of the effort and maintaining the relationship. Implementation moves from planning to action and from general goals to specific tasks, and requires constant assessment to ensure that results of the effort respond to the interests of all stakeholders.

International Collaborative Partnerships for Housing and Community: International collaborative partnerships to address housing and community development issues (ICPHC) are proposed herein. These partnerships are based on the notion that each ecoregion and partner has something important to offer and would benefit significantly from the partnership. Extending the Global Sustainability Network Model, figure 2, to the local scale, ICPHC profit and not-for-profit organizations exchange information, expertise, and dollars to address similar issues (Figure 10). The ICHPC network can be a platform for learning and a laboratory for innovation. As stated by Chesbrough (2003),"Old-school R&D [within large companies around the world] was strictly in-house. The new model for success requires collaboration with many innovators." The new model calls for open innovation, which, "draws on technologies from networks of universities, startups, suppliers, and even competitors."

In the ICPHC initiative partners are identified based on their understanding of housing and community issues from a systemic and regenerative approach. Internet searches, printed information analysis, and on site visits could be conducted to determine compatible partners. Once identified, potential partners can be contacted to share ideas and explore opportunities for collaboration.

Principles of ICPHC Partnerships: As ICPHC partnerships emerge and evolve, stakeholders become aware of the context in which they may operate and important contributions they can make. At the same time, stakeholders can negotiate to establish the principles for collaboration. These principles in turn can help partners establish conditions for implementation (Donaldson and Cozol 1999; Kanter 1994; Dean, Murk, Del Prete 2000). Principles for collaboration should include:

- *Commitment to sustainability*: Partners must embrace sustainability as a regenerative paradigm.
- *Promoting sense of ownership in the initiative*: Partners should consider themselves owners and promoters of the initiative.
- *Maintaining honest and constant communication*: Partners should be confident that open continuous communication helps clarify ideas and move the initiative and its projects forward. Open and honest communication help partners reach consensus to deal with conflicting interests in the partnership.
- *Facilitating empowerment*: Partners should be respected for what they contribute to the relationship and their interests should be protected.
- *Sustaining commitment for action*: Partners must commit to sustain a desire for change and action.
- *Promoting equity among partners*: Partners must have equal rights and responsibilities in decision-making.
- *Developing trust*: Partners must cultivate trust towards other stakeholders and collaborative process.

Conditions for Implementation: There are also conditions to which partners must agree to operate effectively. These define the rules under which partners assume their roles and responsibilities in an equitable and just manner. They provide the general operating structure of the initiative and include:

- *Obtaining legal representation*: Partnerships benefit when they acquire a legal status. Legal status, which is particularly important for funding, may be accomplished by registering each organization in its corresponding country and international organizations such as the Habitat International Coalition.
- *Establishing a formal agreement*: A balance between formal and informal relationships is crucial to sustain momentum and good relationships among individuals. Although institutional agreements help establish broad agendas for action experience shows that each partnership is unique and depends on the level of trust and communication among stakeholders.
- *Defining operational standards*: The establishment of baselines and benchmarks help collaborative organizations measure their level of success and improve the programs.
- *Establishing sense of direction*: Partners define the orientation and scope of their programs by collaboratively defining goals and objectives. Each partner leads its own area and brings important resources to the group. A sense of shared leadership builds as goals and objectives are defined.
- *Defining a plan for action*: Based on the established goals and objectives, partners agree on specific strategies and actions to be taken. They define these strategies and actions in a collaborative fashion.
- *Define roles and responsibilities:* Each stakeholder has a specific role to play and particular interest to protect. The collaborative initiative will be successful to the extent that a clear definition of roles

and responsibilities is established. Roles and responsibilities are defined collaboratively and adopted by partners based on the partners' expertise, economic capacity, and organizational values.

Implementing the ICPHC Initiative: One reason individuals and institutions collaborate is to find tangible timely solutions to difficult situations that they could not find as individual entities. This includes solutions that imply organizational change, and a crucial step in the process of organizational change is moving from planning to action and from individual to global responsibility (Anderson 1999). Implementation is also crucial to sustaining participation and resources. Implementation of the ICPHC requires that:

- *Action plans be documented, monitored, and adjusted*: Documentation becomes an important tool for improvements and dissemination. It is also an important process management tool.
- *Information flow is maintained openly and timely*: Information flow helps partners identify areas for improvement and prevent conflicts or resolve them before they escalate. Open and honest communication helps partners reach consensus to deal with conflicting interests in the partnership. "…achieving consensus requires flexibility and creativity of leaders and members alike in order to deal with differences constructively and reap the rewards of doing so." (Donaldson and Kozol 1999, pg. 105).
- *Assessment be conducted periodically*: Organizations must be willing to assess their success in order to seek improvement or conduct mid course corrections.
- *The success and the lessons learned be disseminated*: Dissemination of results must be part of the agenda to share outcomes and influence others.
- *Partners celebrate their accomplishments*: Celebration important in keeping partnerships alive and evolving. Informal interactions may allow frustrations and potential solutions to emerge.

Links and Communication: State of the art communication can be used by ICPHC members to stay connected, interact, make decisions, plan, and implement programs. Innovative communication systems (two-way video, electronic mail, instant messaging, broadband communication) can all facilitate partner interaction. Periodic on-site visits can reinforce relationship; and partners can get together at least annually in different places to become familiar with partner ecoregions and celebrate accomplishments.

As part of the communication system, members can develop a network of Internet sites with an internal discussion room to exchange ideas. Additionally, to extend the network and its services, a discussion room can be open to the public. This room can include information related to partnership innovations and projects. Ideally, educational institutions can be included in each ecoregion to allow users to take advantage of the research infrastructure and expertise that characterized educational institutions.

Potential Projects: Potential projects that may emerge from the partnership include:

- Internet courses for community residents to address housing and community development projects. Housing and community issues could latter be expanded to other areas (health, legal services, etc.).
- International online educational program in the areas of housing and community development for bachelor and master degree students in different parts of the world.
- International certificate program oriented to practitioners and communities.
- Videoconferences where partners interact with experts from different biomes. These could be part of the educational programs available to the public to increase awareness.
- International workshops to address members' projects or engage in products and services innovation.
- Internet library and best practice database.

Conclusion: The creation of an international partnership network to understand and address local challenges would benefit communities in different parts of the world. Discovering traditional and contemporary vernacular lessons sensitive to natural and social contexts could be of value to partnering individuals and organizations. State of the art technologies could increase idea and expertise exchange, and enhance educational resources for those wishing to learn about other cultures and other ecoregional solutions to similar housing and community challenges.

Collaboration can be a platform for education opportunities, and a strategy to explore innovative ideas to address common concerns across cultures and communities. An international web of experts and learners can collaborate to maximize use of current technologies such as satellite, teleconference, videoconference, and the Internet to interact, make decisions, and learn from each other.

The stages, principles, and conditions of collaboration can enhance partnering among individuals and organizations around the world. Principles based on universal values can help partners establish social and psychological contracts to initiate, evolve, and sustain partnerships. An international partnership carefully designed, implemented, and monitored, can link people, places and ideas for innovation.

Tools for Sustainability in the Knowledge Society

Systems, system dynamics, resource flows and the perceived need to sustain ecobalance have led to life cycle thinking that has progressed steadily from Life Cycle Cost accounting (L.C.C.) to Life Cycle Analysis and Life Cycle Assessment (L.C.A.) to Life Cycle Balancing (L.C.B.) and finally with this chapter the introduction of Life Cycle Space™ (L.C.S.) and Life Cycle Ratio™ (L.C.R.) Each development depends on the one previous with the emergence of the Life Cycle Ratio™ being a direct result of establishing the spatial footprint protocols of Life Cycle Space™ (L.C.S.).

There are many reasons for how the Center for Maximum Potential Building Systems represents space that are beyond the scope of this chapter. They include the incorporation of a geographic equal area projection system for the purpose of graphic visualization and to address the mathematical need for pattern finding around existing life cycle phases within the physical landscape.

The Problem: We are presently living in a world that requires human resource consumption beyond the capacity of a country to live sustainably within its physical boundary in nearly every country except for the poorest. A series of studies by Reese and Wackernagel, available to the public by Sharing Nature's Interest website, tells the story for 152 countries. The problem is how we correct this trend. Unfortunately there is not a clear framework through which we can position ourselves and start to act responsibly. Figure 11 is an equal area GIS rendition of the problem in our country alone – the planet now stands at being 22% over capacity according to the work sited above.

The establishment of Life Cycle Space™ (LCS) as a planning and procedural tool involves the acceptance of a series of conditions. These conditions provide the metrics which enable us to survey geographically and otherwise the spectrum of existing and potential life cycle patterns needed to shift towards a more stable human-environment interface. Various CMPBS projects over the last 28 years have exhibited attributes that hint at these patterns and establish how one can work knowledgably with a region's resource base (virgin and by-products), labor skills, and enterprises to fit patterns that provide the next step systemic conditions for directed change. The approach in this section begins to provide the logic necessary to support the assertion that a region can best be sustained by regionalizing resource dependencies rather than national and international life cycle dependencies. The Life Cycle Space™ reduction approach herein should help us shift our understanding of buildings, building systems and a wide range of sustainable human activity. L.C.S.™ and L.C.R.™ are based on sixteen fundamental conditions that are co-dependant (i.e. for the most part not able to stand alone without the recognition of the other conditions). It is assumed that all applications of these conditions are based on renewably based technological process where nature and the solar constant are the driving forces.

1. The life cycle is made up of links and nodes. Links contain four principle flows: materials (solids, liquids, gases), energy (all forms renewably derived), money, and information. Nodes are defined according to basic life support needs (air, water, food, energy and materials).
2. Land as a natural resource can be planned using long term sustainable management practices once suitability analysis is accomplished to identify the lowest impact and highest use suitability areas for particular life cycle practices.
3. Incorporation of self similarity and redundancy between life cycle topics at several scales, (i.e. biomes and watersheds, building site) must occur so as to reduce possibility of system failure.
4. Efficiency of overall life cycle is often increased by reduction in the number of transformation activities (nodes).
5. Reducing life cycle distances (links) between life cycle activities (nodes) relative to the basic human physiological needs (nature sourced air, water, food, energy, and materials) starts with the smallest scale and progresses only to larger scales of life cycle use as necessary.
6. All life cycle activities occur with definable boundaries either naturally or artificially derived in order that life cycle performance can be measured.
7. Increasing diversity within the life cycle including all 5 kingdoms within the overall life cycle or within constituent phases increases the health of the system by blocking disease throughput.
8. Reducing the need for larger life cycle scales by establishing multipurpose and/or highly integrated stages within the life cycle.
9. Reducing complexity of the life cycle (as in #2) so that the quality of information needed by humans is manageable.
10. Extending the use phase of life cycle by repair and maintenance necessitates accompanying increases in resource allocation for this activity by planning the life cycle accordingly.
11. Increasing the adaptability (flexibility) of life cycle elements through separation of physical structure from the function permits openness regarding how structures are placed on the land.
12. Establishing place-based economic loops at all scales by purposely tying life cycle activity nodes to area resources and neighboring enterprises.
13. Life cycle balancing those sourced products supplied by nature through the use of the necessary land area required for regeneration re-sourcing methods at each node or combinations of nodes for the life cycle within a defined boundary scale.
14. Measuring by ratio the sourcing and re-sourcing life cycles according to a set boundary scale.
15. Establishing a pattern recognition procedure that codes possible life cycle patterns for purposes of measuring existing and potential balancing.
16. Establishing points of entry into the existing system through network analysis whereby potential technological and sociological “triggers” can be identified.

The following sections describe several of these conditions more fully and in some cases links conditions to the NIST Incubator project at Montana State University. It is assumed that a second phase of this work would enable more complete and measurable understanding of the Life Cycle Space™ process.

Conditions of Life Cycle Space™ Described: Several conditions are described more fully in the text below. For space saving purposes other conditions are left out.

Condition #3 Incorporate Nature's Safety Net of High Redundancy and Self Similarity Within and Among Living Systems into the Built Environment.
Condition #1 recognizes the condition of duplication in structure and function at a variety of scales so that the human-nature system remains robust and healthy. Sustaining levels of redundancy is key to understanding performance because a certain amount of resource (energy, materials, information storage etc.) must be put aside to guarantee system performance. The importance of understanding boundaries is the essence of Life Cycle thinking and a sustainably built environment. The intricacies of these scales, types, and relationships are addressed in other papers. If the reader wishes more familiarity with this concept, please contact P. Fisk and D. Armistad. A useful description of these boundaries is found in papers by di Castri, Reference (2) and Figure 12.

Condition #5: Increase efficiency through miniaturization of the life cycle within a regional or site context.
This Condition states that priority should be placed on providing for the incorporation of all possible processes (or transformations) at the smallest possible scale thus relieving the burden of impact necessitated by the sole use of larger life cycle systems. This Condition requires the recognition of the Life Cycle sequence as a fundamental planning tool, Figure 13, and that the process within each life cycle overlaps and serves in a multi-functional manner into another life cycle as described in Condition #1. The efficiency of the life cycle process rises when fewer individual or separate transformations occur, Figure 14.

Condition #9: The technology of production and use at smaller scales can only compete with those at more centralized larger scales if they become multipurpose and highly integrated.
There is a common belief that larger scale, centralized technologies are more efficient and environmentally superior to smaller scale operations due, for example, to effective centralized pollution control. However, trends show that with improved technology and enhanced integration between technologies, there is a greater possibility to achieve a balance in material and energy flows at all phases of the life cycle, Figure 15. Simply stated, integration is a more important concept in life cycle design than is conservation.

Condition #10: Reducing the complexity of the life cycle enables it to relate more directly to the amount of information processing by all actors involved, from design and engineering integration to users and environmental impact assessment.
Working with simplified construction and mechanical systems aids both in information gathering and processing for environmental impact evaluation, and the ability to integrate one technology with another. Figure 16 summarizes the information and complexity issue.

Condition #11: In architecture, plan for an extended use phase of the building's life cycle.
The condition relates to the length of time attributed to the use phase of a building, its environmental impacts, and the long-term economic investment that a society places in the built environment. Design features such as flexibility, reuse, and material longevity lengthen a building's useful life which, in turn, can affect the useful life of a building's predominate materials. By building in an anticipatory manner, easily removable structures pay for themselves in terms of embodied energy and other resource uses several times over. This rule reflects the disproportionately large investments made for rebuilding and

remanufacturing vs. this money used for other investment practices which could reap greater social benefits. Figures 17 and 18 illustrate the resource and investment trends based on a structure's useful life.

"By increasing the durability of construction and renovation to 400 years would generate a 5 to 10 fold increase in the economic productivity of our resources and would reduce the economic cost of construction 80%-90%" – Tom Bender, Winner, California's Affordable Housing Competition 1983. According to Frances Duffy, capital invested into a structure over a 50-year period is overwhelmed by the cumulative financial consequences of three generations of services (no underline) and ten generations of space. When combined, these end up costing approximately five times the cost of the structure.

Condition #13: Support regionalized economic loops by respecting tight knit life cycle integration. Each stage of the life cycle becomes a part of the region's economics.
Life Cycle Economics promotes the close alignment of economic benefits with the benefits of designing highly integrated material and energy flows where wastes are considered as valuable as virgin resources. Linking economics and ecology, as practiced by industrial ecologists, develops the "tightness" necessary to achieve healthy, ecological, and economic facilities and regions.

Condition #14: Life cycle balance those sourced products supplied by nature through the use of the necessary land area required for regeneration re-sourcing methods at each node or combinations of nodes for the life cycle within a defined boundary scale; Condition #15: Measure by ratio the sourcing and re-sourcing life cycles according to a set boundary scale; Condition #16: Establish a pattern recognition procedure that codes possible life cycle patterns for purposes of measuring existing and potential balancing.
Taken together conditions 14, 15, and 16 are represented in figures 19 and 20. Starting with the definition any process being represented by the life cycle at whatever scale we are working, we then start dissecting this generalized pattern until we understand the missing elements of a particular pattern that needs to be balanced. The generalized pattern (there are 136 prime patterns and 100's of secondary patterns) are then selectively described by number and explained using simple examples so the reader can understand the pattern recognition exercise.

Pattern Descriptions: A limited description of the generic patterns in Figure 11 summarizes its potential use. The codes S1.0, R7.0, S7.0 / R1.0, S2.0 are described in the following text. Then specific examples at different scales are diagrammed using the second level specification (Fig. 10). The latter demonstrates balanced energy, water, food and sometimes material conditions relative to the specific subject topics. These examples have yet to be coded according to figure 11 above.

S1.0 exemplifies a Life Cycle Space™ dominated by the re-sourcing part of the life cycle. The condition rarely occurs to create total balance of the re-source, but is reminiscent of third world conditions where there is a large presence of garbage pickers who have derived hundreds of ways to recycle waste dumps, unfortunately in very unsafe manners.

R7.0 occurs when Life Cycle Space™ is dominated by the sourcing part of the life cycle. Representative of third world extractive conditions that are exploitive leaving no provision for balancing the materials or energy extracted.

S7.0 / R1.0 occurs when L.C.S.™ is in a near balanced state and the ratio of source to re-source is 1. Examples of this occur primarily in highly integrated farming, industrial ecology passive solar architecture, water harvesting and treatment and depend on the defined topic areas being considered for balancing. Figures 21-23 fit this example:

Life Cycle Space™ Conclusion: Buckminister Fuller stated that "A geodesic is the most economical relationship between any two events." The implications of Life Cycle Space™ is dependent on how nodes are configured in a manner that integrates processes and thus shortens linkages. The degree of balance within a given spatial context (boundary scale) must relate heavily on our understanding of a broad spectrum of ambient resources. The careful matching of nodal (processes) to these ambient resources in multiple fashions determines the Life Cycle Space™. At this time there are over 12.5 million businesses in the U.S. with the only procedural linkage being the Input/Output model of the U.S. economy. The spatial positioning on GIS of each business, its product and by-product condition, along with its relation to regional resources could enable various degrees of Life Cycle Planning.

Looking Forward: Sustainability for the Americas and Global Sustainability Consortia

The USBSC is the pilot program of LDI's Sustainability for the Americas Consortia Initiative. Based on USBSC successful emergence, seeding and implementation start-up, LDI has recently facilitated emergence of the North American Sustainability, Housing, and Community Consortium (NASHCC). The NASHCC moved rapidly through its emergence and seeding phases, and has submitted proposals to FIPSE and its Department of Education counterparts in Canada (HRDC) and Mexico (SEP). Upon receipt of FIPSE-HRDC-SEP or other multi-year funding, the NASHCC will have entered its Implementation Start-Up Phase.

The NASHCC is the case-study for expanding the USBSC to address sustainability, housing and community. It also serves as the model for other Sustainability for the Americas sustainability, housing and community consortia. The Sustainability for the Americas network likewise serves as the model for the global network that pursues regional and global sustainability through innovation.

People interested in inter-national sustainability consortium are invited to contact the authors to discuss partnering to increase understanding of existing and innovative models for sustainable technologies and design based on analysis of strengths, weaknesses, opportunities, and threats (SWOT) resulting from relationships among technologies and sustainable resource-flows in their region. We look forward to partnering to evolve sustainable solutions including commercialization of sustainable technologies for local or global regions.

Bibliography

Anderson, R.. Mid-Course Correction: Toward a Sustainable Enterprise. Atlanta, Georgia: Peregrinzilla Press, 1998.

Ayres, R.U., “Industrial Metabolism.” *Technology and Environment.* Washington D.C.: National Academy Press, 1989.

Barabási, A. L.; “Linked: The New Science of Networks”, Perseus, Cambridge, 2002, p. 56-8.

Byrne, J. & Brandt, J. The virtual corporation-cover story. *Business Week,* 18, Feb. 1993, 98-102.

Castells, M.; “A Sociedade em Rede” (“The Rise of the Network Society”), Paz e Terra, São Paulo, 1999.

Chesbrough, H. Reinventing R&D Through Open Innovation. Strategy+Business. Retrieved April 30, 2003 from the site http://www.strategy-business.com

Dean, G., Murk, P., and Del Prete, T. Enhansing Organizational Effectiveness in Adult and Community Education. Malabar, Florida: Krieger. 2000.

di Castri, F. “Enhancing the Credibility of Ecology: Interacting Along and Across Hierarchical Scales.” GeoJournal, Kluwer Academic Publishers, 1988.

Donaldson, J. and Kozoll C. Collaborative Program Planning: Principles, Practices, and Strategies. Malabar, Florida: Krieger Publishing Company. 1999.

Duffy, F. & Hanney, A. *The Changing City*. London: Bullstrode, 1989.

Evans, P.; “Embedded Autonomy – States and Industrial Transformation”, Princeton University Press, 1995.

Fisk, P. Integration vs. Conservation, A Renewable Energy Building Block for the 21st Century, American Solar Energy Society Proceedings, 1989.

Fisk, P. & Armistead, D. “Towards Resource Balanced Land Use Planning (The Emergence Of Life Cycle Space™), 7th International Conference on Technology Policy and Innovation, Monterrey 2003, Monterrey Institute of Technology, 2003.

Fisk III, P., MacMath, R; Ramina, R. H.; “Industrial Ecology as a Regional Planning Tool: A New Potential for Economic/Environmental Regional Planning”, 4th International Conference On Technology Policy And Innovation, Curitiba, Brazil, August, 2000

Flavin, C. Power Surge. Worldwatch Institute, 1995.

Friedman, Y. Critical Group Size Architectural Design. London. January 1973.

Friedman, Y. Towards a Poor World – How Scarcity Might Prevent Disaster Architectural Design. London. October 1973

Fuller, B. *Explorations in the Geometry of Thinking Synergetics*. New York: Macmillian Publishing, Inc, 1982.

Gibson, D. V. et al.; AIncubating and Networking Technology Commercialization Centers among Emerging, Developing and Mature Technopoleis Worldwide@, IC5, The University of Texas and Austin, s.d.

Gielen, D.J. "Western European Materials as Sources and Sinks of CO2, A Materials Flow Analysis Perspective." *Journal of Industrial Ecology*, School of Forestry and Environmental Studies, Yale University, MIT Press, vol. 2, no. 2, 1998.

Hatchuel, A.; Agrell, P; van Gigch, J.P. "Innovation as System Intervention". Systems Research: The Official Journal of the International Federation of Systems Research. Vol. 4, #1, 1987.

Horzepa, S.; "Your Gateway to Packet Radio", The American Radio Relay League, 1989
Meadows, Donella H., "Whole Earth Models and Systems." *The CoEvolution Quarterly*.

Kanter, R.. Collaborative Advantage: The art of alliances. Harvard Business Review, 72 (4), 96-108, 1994.

Miller, J.G. *Living Systems.* New York: McGraw-Hill Book Company, 1978.

Motloch, J.L. Partnering for Regional and Global Sustainability, 7th International Conference on Technology Policy and Innovation, Monterrey 2003, Monterrey Institute of Technology, 2003.

Motloch, J. L.; BSU Land Design Institute Education for Sustainability, Lowell MA 2003

Motloch, J. L.; "Introduction to Landscape Design", John Willey & Sons, 2nd. ed., 2001.

Motloch, J.L. and Ferguson, D.L. "The LandLab as a Hands-on Tool for Teaching Sustainable Concepts", Greening of the Campus II, 1997

National Academy of Science. *Food, Fuel and Fertilizer from Organic Waste*. Washington DC: NAS, 1981

National Academy of Science. *Making Aquatic Weeks Useful: Some Perspectives of Developing Countries*. Washington DC: NAS, 1976.

National Geographic Society. 2000. Terrestrial ecoregions of the world. From the site www.nationalgeographic.com/wildword

"One General Theory of Living Systems." Scientific American.

(16) O'Neill, R.V. et al. A Hierarchical Concept of Ecosystems. Princeton: Princeton University Press, 1986.

Pacheco, P.D., "Partnering Globally: Connecting People, Places, And Ideas For Sustainable Development", 7th International Conference on Technology Policy and Innovation, Monterrey 2003, Monterrey Institute of Technology, 2003.

Pauli, G. 1998. Upsizing: The road to zero emisions, more jobs, more income, and no pollution. Sheffield, UK: Greenleaf Publishing

Poungsomlee, A. & Ross, H.; "Impacts of Modernization & Urbanization in Bangkok: an integrative ecological and biosocial study"; UNESCO MAB, Institute for Population and Social Research in Mahidol University, Thailand and Centre for Resource and Environmental Studies at Australian National University, Australia, 1992.

Prahalad, C. and Hart S. 2002. The Fortune at the Bottom of the Pyramid. Strategy+Business. Strategy+Business. First Quarter. Retrieved March 20, 2003 from the site http://www.strategy-business.com

Ramina, R.H. "Networks and Communities: Sustainability in the Knowledge Society", 7th International Conference on Technology Policy and Innovation, Monterrey 2003, Monterrey Institute of Technology, 2003.

Ramina, R. H.; "CONNECTION - Some Thoughts for the Conceptualization and Design of an International Network Based on Amateur Packet-Radio"; mimeo, International Program for the Study of Communication for Sustainable Development, Ryerson Polytechnical Institute, Toronto, Canada; 1993.

Ramina, R. H.; "Redes e Poder: o Processo de Metropolização e a Gestão dos Recursos Naturais" ("Networks and Power: The Metropolization Process and the Management of Natural Resources") Ph.D. thesis; Universidade Federal do Paraná, Doutorado em Meio Ambiente e Desenvolvimento, Curitiba, 2000.

Rapoport, A. House form and culture. Englewood Cliffs: Prentice-Hall. 1969.

Reese, W. and Wackernagel, M. *Our Ecological Footprint*. New Society Publishers, 1996.

Tipps, H. "Industrial Ecology." Whole Earth Review. Winter 1992.

Tribus, M. & McIrvine, E.C. "Energy and Information."

United Nation Development Programme. Human Development Report of 1999,

United Nations Environmental Program (UNEP). Civil Society and NGO Unit. 2002. Enhancing civil society engagement in the work of the United Nations Environment Programme. CSC Strategy paper. http://www.unep.org/dpdl/cso

Zeri Foundation (Zero Emissions Research and Initiatives). www.zeri.org.

	Regional Population (% of world population)	Internet Connections (% of regional population)
USA	4,7	26,3
OCDE (USA excluded)	14,1	6,9
Latin America and Caribbean	6,8	0,8
Southeast Asia and Pacific	8,6	0,5
East Asia	22,2	0,4
Eastern Europe and CEI	5,8	0,4
Arab Countries	4,5	0,2
Subsaara Africa	9,7	0,1
South Asia	23,5	0,04

Table 1: **Regional Concentration in Internet Access**
(Source: NUA 1999; Network Wizards 1998; IDC 1999)

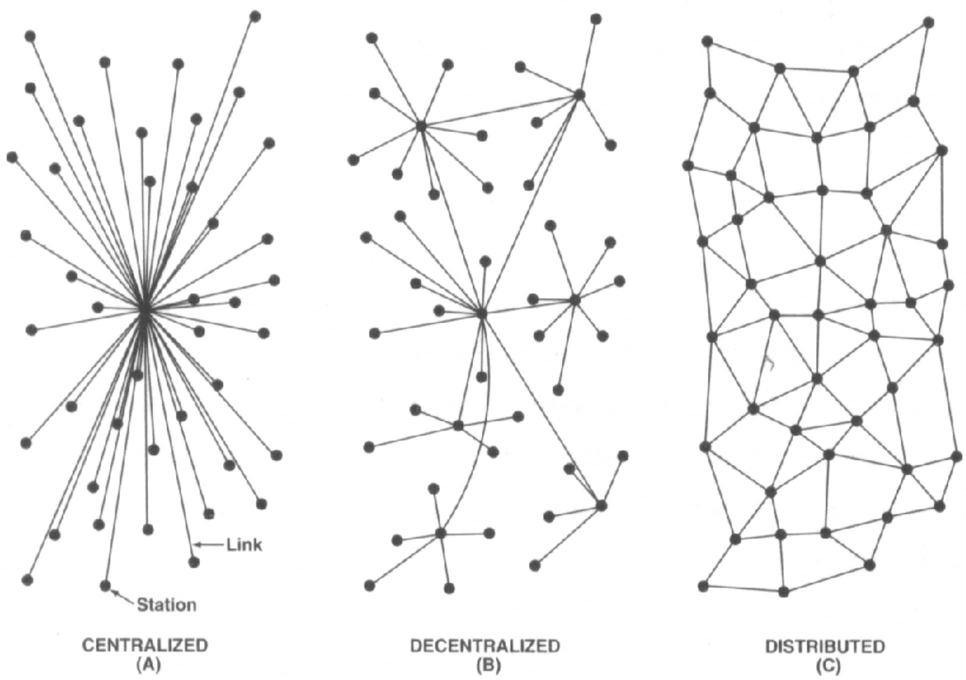


Figure 0 **Network Architectures**
(Source: Barabási, 2002, p. 145)

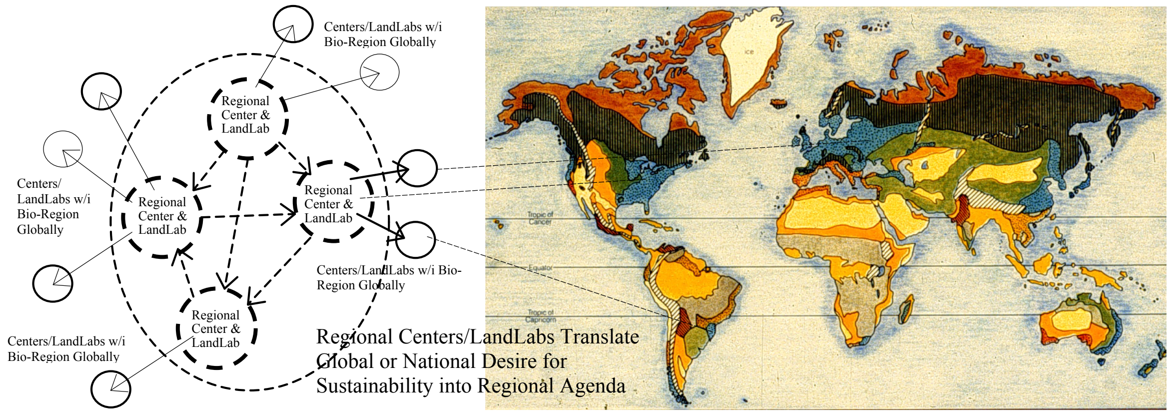


Figure2. LDI's Global Sustainability Network of Regional Centers/LandLabs Evolved (Motloch 2003) for Motloch and Ferguson (1997)

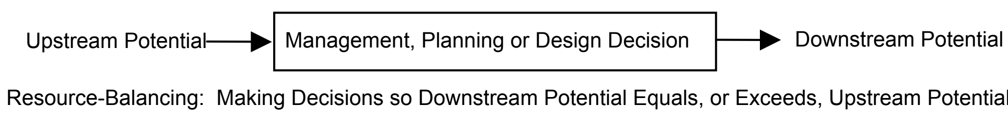


Figure 3. Resource-Balance

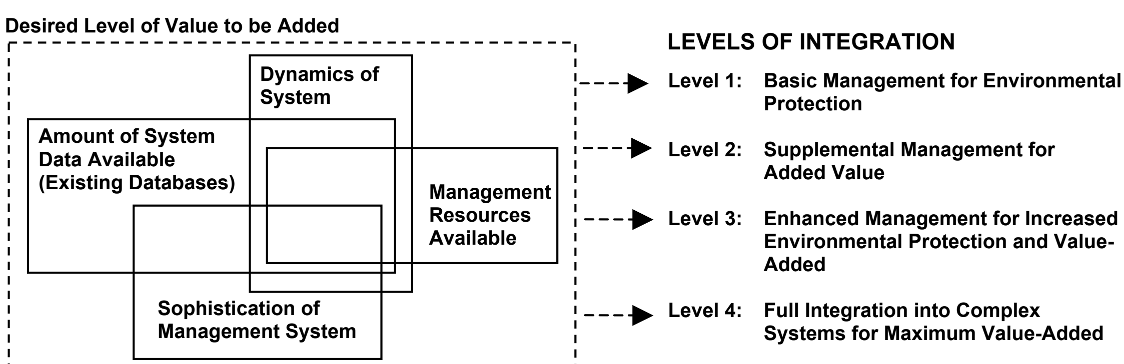
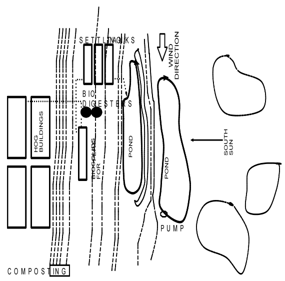


Figure 4. Appropriate Value-Added Level

Existing Brazilian Integrated Farm Benchmark Project: Suinocultura Irno Pretto Project



Current Operation

- Produces pigs, fish, chickens, agriculture
- In region with aquaculture tradition (monoculture supported by large amounts of purchased fish food)
- Farm employs 28 people in 300 hog operation
- Produces pigs for sale
- Harvests biogas from waste; Uses biogas to pump water among ponds
- Ponds lined with elephant grass for fish food
- Algae serves ponds and tanks
- Farm produces sludge fertilizer
- Young pigs that die are composted; Pigs above 15 kilos are cut up & composted
- Tough parts of elephant grass composted with pigs, wood chips, water

Figure 5. Sustainability through Integration into Complex Systems

STAGE 1: CONSORTIUM EMERGENCE
ID Partners
Visioning Workshop

→ STAGE 2: CONSORTIUM SEEDING
Support–Building
IInst. and Project Visits

→ STAGE 3: IMPLEMENTATION START-UP
Initial Academic & Project Funding

→ STAGE 4: SUSTAINED IMPLEMENTATION
Long-term Academic & Project Funding

Figure 6: Process for Building a Sustainability Consortium

STAGE 1: CONSORTIUM EMERGENCE →

Summer, 2002 Partners identified; Two-day Visioning Workshop; each partner identified goals & interests in relation to consortium, resources organization brought to team, supports needed from team, potential constraints to participation, and view of consortium potential.

STAGE 2: CONSORTIUM SEEDING →

Seeded Summer & Fall 2002; 10-day trip Brazil; Meetings; Testing & Upgrading distance education compatibilities; Visits to benchmark projects, favelas, and computer game-development incubators; Development of list of projects (six sustainability knowledge-building projects, three sustainability educational game projects, one energy production demonstration project, two green-building demonstration projects, three community capacity-building sustainability projects, and eight sustainability visualization projects.

STAGE 3: IMPLEMENTATION START-UP →

March 2003, parallel four-year US-Brazil Sustainability Consortium academic funding proposals (FIPSE, US DOE & CAPES, Brazil DOE; Late June announcement)
Two World Bank Development Marketplace proposals (one in U.S.; one in Brazil) April 2003. Project ideas positively reviewed by international funding agency. Meetings pending.

STAGE 4: SUSTAINED IMPLEMENTATION

Present: Continuing to develop program of long-term sustainability projects to lead society to sustain consortium over long term. Includes major value-adding integrative technology programs, distributed energy programs, resource-balancing programs, & institutionalization of consortium through major project, agency, and international foundation funding.

Figure 7: Process of Building U.S.-Brazil Sustainability Consortium

Figure 8: U.S.-Brazil Sustainability Consortium Structure

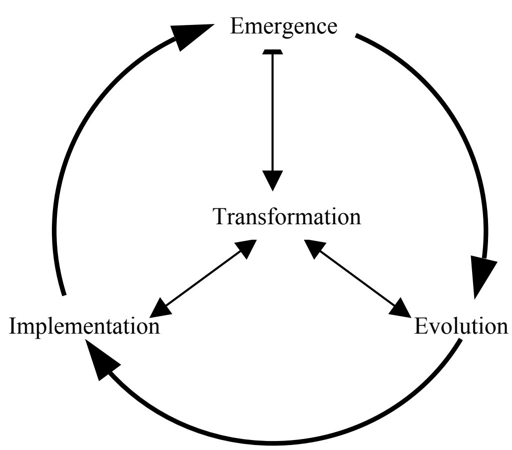


Figure 9. Developmental stages of collaborative relationships (Donaldson and Kozol 1999).

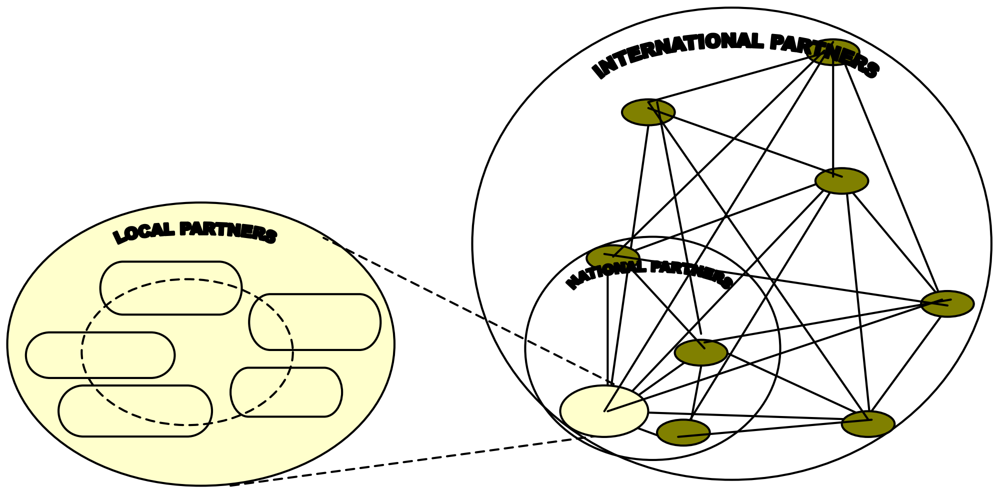


Figure 10: International Collaborative Partnership

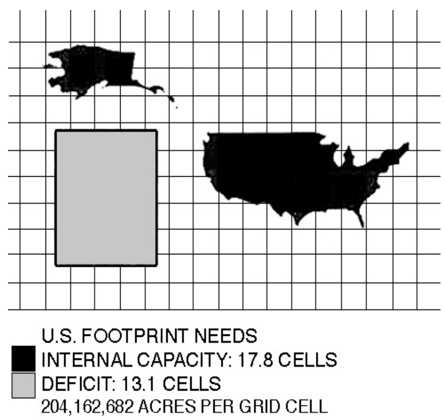


Figure 11 Overshoot in Area Needed to Sustain US Population

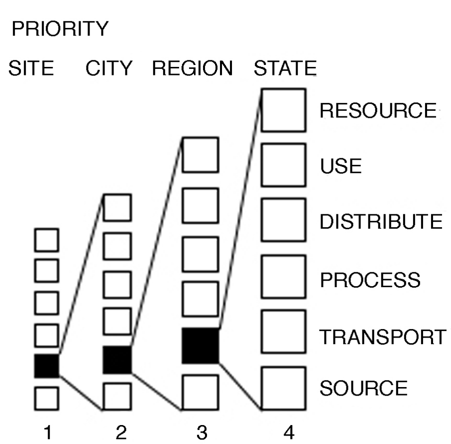


Figure 12: Condition of Systems within Systems, Reference (2)

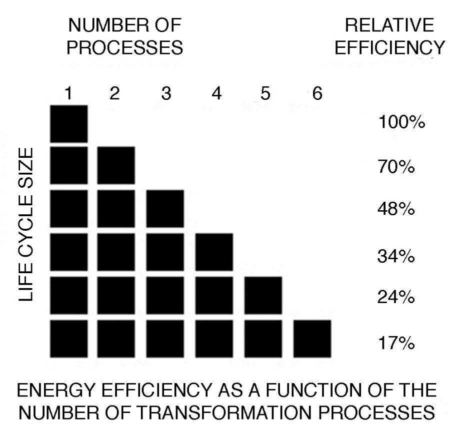


Figure 13 Efficiency Reduction according to number of Life Cycle Phases (below in built environment terminology), Reference (1)

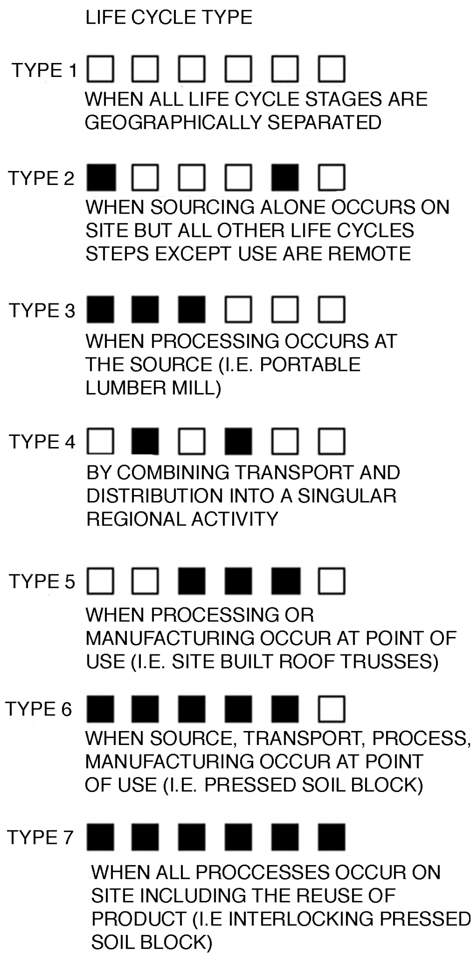


Figure 14 Examples of first level reduction in number of Life Cycle Phases

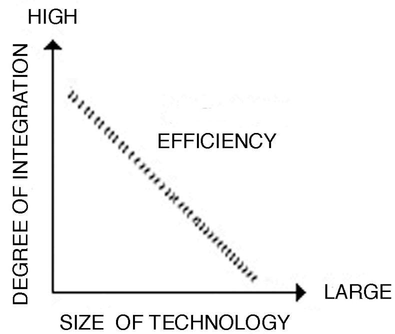


Figure 15: References (5), (4)

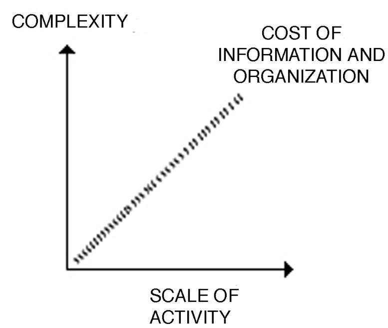


Figure 16 Relationship of Complexity, Information and Cost, References (6), (7)

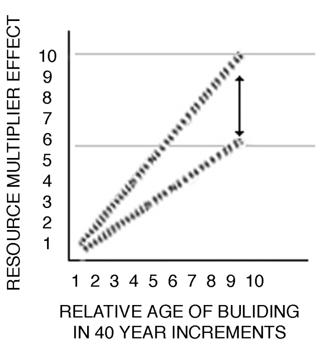


Figure 17: Resource Use and Age of Facility with unplanned Obsolescence

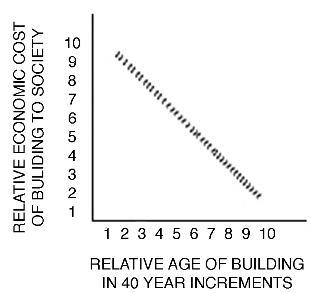


Figure 18: Cost and Age of Facility with unplanned Obsolescence

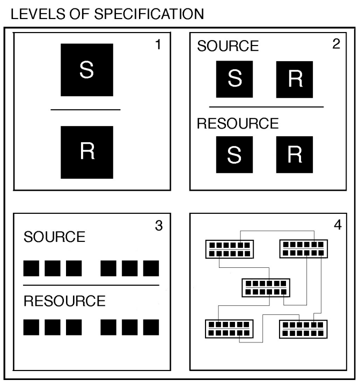


Figure 19: Levels Specificity in coding Life Cycle Ratios

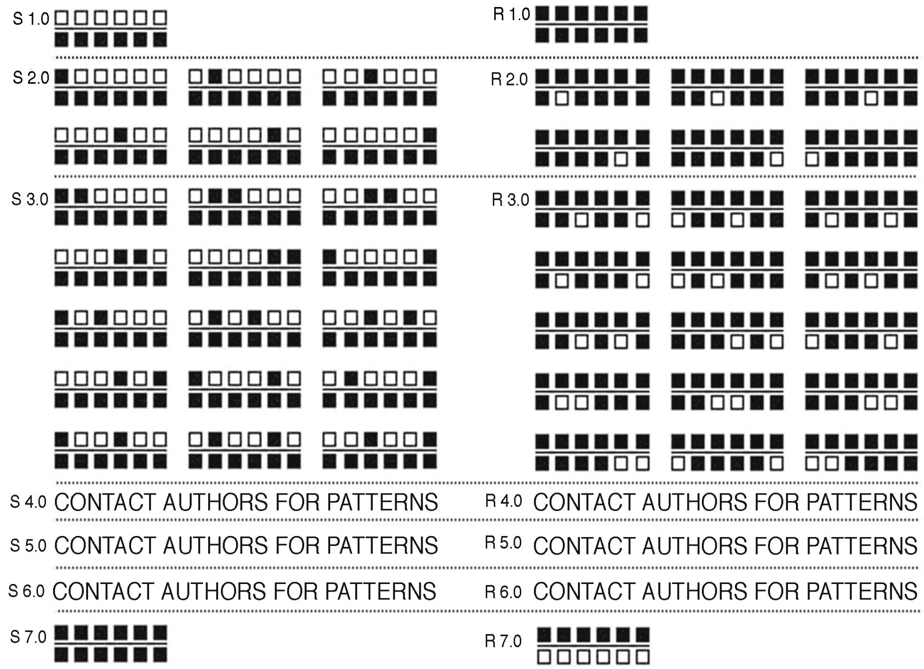


Fig 20: Life Cycle Balance Ratios in form of Pattern Generation for purpose of coding existing conditions can be applied at multiple facility scales from whole regional landscapes to specific facility

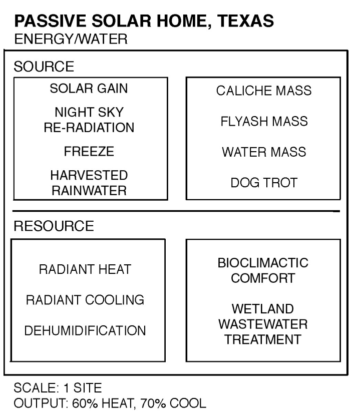


Fig. 21: Energy / Water Balance at site Scale

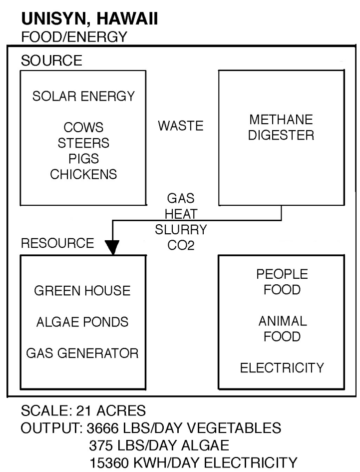


Figure 22: Food / Energy Balance in Integrated Farming

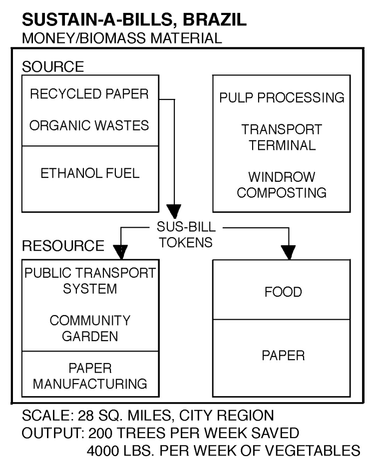


Fig. 23: Money /Material Balancing at Urban Scale