Constructing a Sustainable Urban Regenerative Proposal for Kyoto, Japan

BASHIR A. KAZIMEE and TOM J. BARTUSKA
Washington State University

Sustainability is being mandated by numerous international and national directives. These mandates challenge the design and planning professions to create truly livable and sustainable environments. These directives carry a forceful message that society must address the challenges posed by this inclusive and elusive concept (Boyer, 1996; NSTC, 1995; ACSA/AIA, 1994; ASLA, 1994; AIA/UIA, 1993; CEM, 1993; AIAS, 1992).

Sustainable programs require a comprehensive and integrated understanding of a city's unique human and environmental resources. By definition, sustainability identifies strategies that look at a community's on site natural resources as integral aspects of the design (Vieria, 1993). It integrates natural systems with human patterns and celebrates continuity, uniqueness and placemaking (Early, 1993).

The sustainable regenerative proposal for Kyoto is based upon ecological or biological modeling techniques which carefully balance on site interchanges between the unique human and environmental systems of the city. These ecological interchanges become important indicators for sustainable development and defines inherent qualities, carrying capacities, and the required ecological footprint of this internationally renown city. This approach allows Kyoto to model, measure and program a series of design strategies for sustainable development. The sustainable proposal also enhances Kyoto's "Basic Policies for City Development" (Kyoto, 1997) while demonstrating how the city can and must integrate human and environmental issues into a regenerative design process. These basic policies are: A) Human-Centered Healthy Environment, B) Focus on Conservation, Renewal and Creation, C) Productive Artistic and Cultural Center, and D) City with a Global Vision.

Kyoto's directives are clear, if not profound, but the process is far less established. Based upon these policies, Kyoto and the related design/planning professions must continue to determine and agree upon definitive ways to define, model, measure and achieve sustainability.

There are many definitions of sustainability. This diversity is both an advantage and disadvantage. In review of the plurality of this term, the site or the urban-regional context is an important variable to most working definitions of sustainability. This emphasis is expressed in the following composite definition which was used to construct the proposal:

> Sustainable developments are those which fulfill present and future needs (WECD, 1987) while [only] using and not harming renewable resources and human-environmental systems of a site: air, water, land, energy, ecology, and/or those from other off-site sustainable systems (Rosenbaum 1993 and Vieria 1993).

Sustainable Indicators for a Comprehensive Regenerative Process

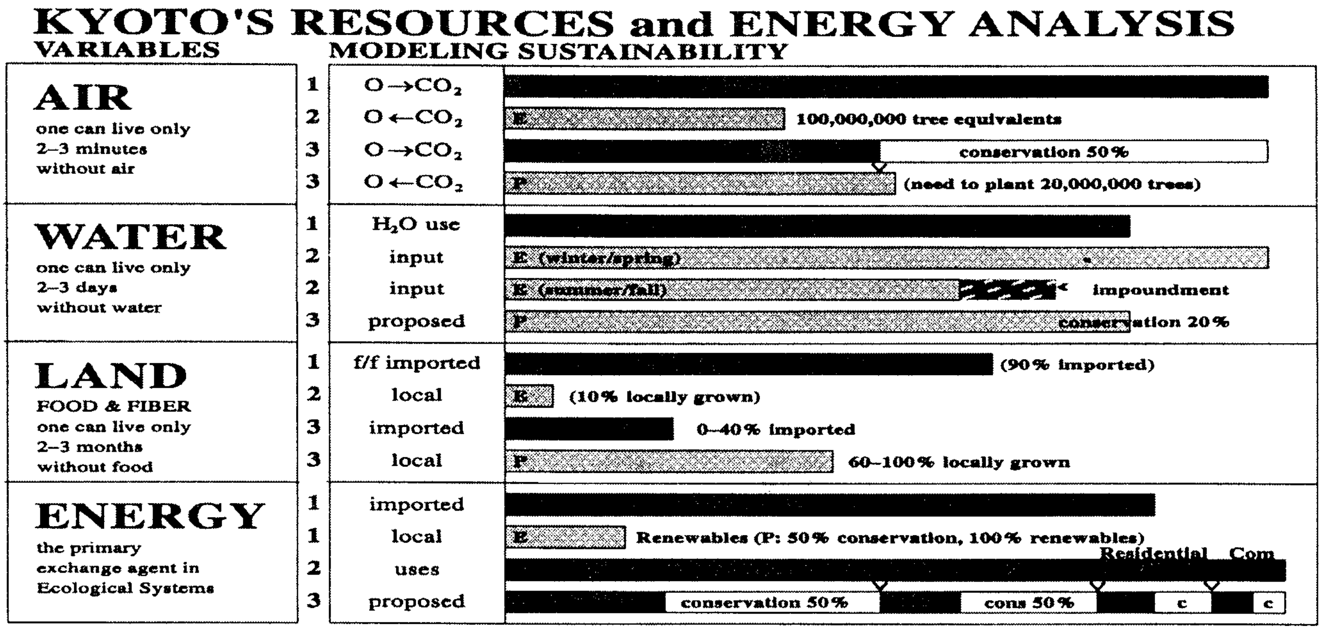
Although the Kyoto's ***site*** or land area is definable, its natural cycles are primarily invisible and transcend artificial boundaries (building site, city, region or even the national scale). Many sustainable developments strive for self-sufficiency by attempting to operate independent of imported resource and energy systems. The amount or percentage a development uses the renewable human and environment resources of a ***site*** is a useful **"indicator"** or measurement of its sustainability.

Sustainable indicators are commonly generated and agreed upon by a city and its citizens. This study recommends an active community process. Kyoto's policies are compatible with the proposed set of ecological or biological variables (air, water, land, energy and human ecology). These fundamental human-environmental exchanges of the city's ***site*** were used in developing critical "input/output" modeling techniques to direct this proposal's regenerative process. This ecological method illustrates the challenging requirements for programming, measuring and achieving sustainability. These selected dynamic networks of human and environmental interrelationships are diagrammed in Figure 1 and further discussed in the concluding addendum.

The related ecological exchanges between the selected human-environmental systems of air, water, land (food and fiber) and energy for the city are quantified and illustrated in Figure 2 and further discussed in the concluding addendum of this paper. Each ecological interchange has been calculated and the bar graph illustrates in relative quantities of the following relationships (Bartuska and Kazimee, 1994):

1. The existing use of each resource.
2. The non-renewable and renewable supply of each of the resources available from the Kyoto site.
3. The proposed sustainable use and estimated percentages of conservation required to place each human-environmental system in balance.

The modeling of each relationship is important in determining the various regenerative strategies for sustainability. The method demonstrates the interaction of each system and that 20-50% conservation is required to place each resource exchange in a sustainable balance. The authors have also applied this methodology to their university city, Pullman, Washington, USA. The imbalances were substantially higher-requiring 40-70% conservation. Their proposal received a gold medal at the recent Habitat II conference in Istanbul, Turkey (IAA, 1996). The Pullman proposal can be reviewed at www.arch.wsu.edu/~sustain. The method used for both case studies



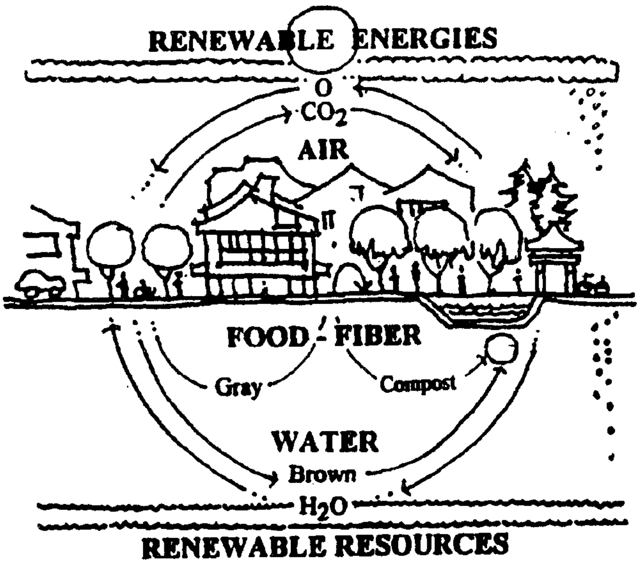


Fig. 1. Concept diagrams of sustainable cycles and graph illustrating the modeling of the selected ecological variables for Kyoto.

conveys an invisible surprise, that air represented by CO_2/O (carbon dioxide to oxygen) exchange achieved through photosynthesis is one of the most overlooked yet fundamentally critical and representative of all the indicators. Driving the air exchange imbalance is the use of energy, especially the combustion of fossil fuels by automobiles and trucks, the largest consumer of air and energy. Truly sustainable developments will require a significant priority shift to pedestrianization and transit priorities within the city, its districts and neighborhoods, causing a substantial reduction of vehicular use and a proven increase in the quality of a city.

Kyoto's Comprehensive Urban Design Strategies for Sustainable, Regenerative Development

The above definitions and modeling techniques provide a method to carefully balance on site human and environmental ecological systems. Within the context of this ecological model, various scales of developments were studied. These modeling techniques generate the resultant sustainable design strategies for the city's regenerative process. Many of the selected design strategies and technologies are derived from successful, sustainable principles used in vernacular and contemporary societies. By definition, vernacular developments have sustained the test of time and have celebrated harmonious societal development without the use of non-renewable resources and energies. The study demonstrates the integrated use of these modeling methods and sustainable design strategies in the revitalization of Kyoto, enhancing its human, economic, social and environmental quality.

The following is a summary of the proposed design and planning strategies which can guide Kyoto towards a comprehensive program for the 21st century. The design strategies, although highly interrelated are listed under the four scales of urban construction: **region, city, district-neighborhoods, and residential** development.

REGIONAL DESIGN STRATEGIES were found to be necessary in providing a critical opportunity to balance selected human-environmental interchanges. The urban district was inadequate in size to be sustainable. The enhancement and maintenance of the green belt and water impoundment systems are necessary to balance air exchanges (O–CO_2); water cycles (precipitation=H_2O use); land and its food/fiber processes (gardens, urban forests and reducing/reusing/recycling of resources); energy use (conservation and use of renewable resources). The critical ***regional design strategies*** are summarized below (ref. Figures 3 and 4):

A. Kyoto's extensive green belt moderates climate extremes, increases recreational opportunities and bio-diversity. Although the green belt is very extensive, it needs to be extended by 25% to balance the O–CO_2cycle. These green programs should use primarily indigenous landscaping which conserves water, reduces maintenance and celebrates the unique qualities of this region. Family farming is also encouraged in allotment gardens in the green belt. Numerous farmer's markets continue to foster local agricultural produce and handicrafts.

B. Kyoto has adequate precipitation to equal water use but policies and programs need to be established for the abundance of spring water runoff to be retained in balancing lakes to supplement dry seasons. These strategies would also reduce spring flooding; filter eroded soils; improve water quality, fishing and recreation potential; and increase biodiversity.

C. The increased costs of non-renewable energy in the 21st century

Fig. 2. Regional and city sustainable plan.

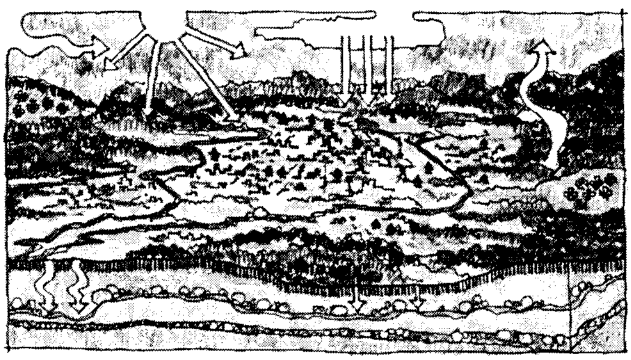


Fig. 3. Regional and urban ecological processes.

Fig. 4. Water impoundment within region and city.

will continue to create a positive shift to conservation and renewable resources. Kyoto's proposed community's sustainable energy budget comes from 30% regional hydropower, 60% solar and photovoltaics and 10% wind farms in the green belt.

CITY DESIGN STRATEGIES provide for a nested hierarchy of central places (city, districts and neighborhoods) supported by an effective infrastructure. Kyoto's traditional grid pattern is reinforced and celebrated in a polygrid or multiple grid pattern emphasizing pedestrianization, bikeways and transit (while accommodating vehicular transportation). The infrastructure emphasizes public transit and pedestrian greenways. The clustering of activities increases pedestrian enjoyment and accessibility. The critical city design strategies are summarized below (ref. Figures 3 to 8):

A. The reanimation of the historic city center is facilitated by its ideal, centralized geographic position. The clustered restructuring of the central city and the new rail/transit center fosters incentives for economic growth and establishes a dynamic central focus for Kyoto.

B. Design priorities are given to pedestrian and public transit systems. The clearly defined greenways and transport systems throughout the city make a substantial reduction in auto use of nonrenewable energy. This is the single most important strategy in balancing the CO_2 to O cycle and improving air quality in the community.

C. Building codes increase energy conservation standards, currently 50% better than the 1985 buildings to 70% in the year 2000. Due to advancements in efficiency, the use of solar design strategies and photovoltaics, many advanced buildings can actually add renewable energy to the city's supply.

D. Resource management (traditionally waste disposal) becomes self-sufficient by adopting priorities to first reduce, then reuse and recycle. The model fosters community enterprises based on sustainable resource use, reuse and recycling.

DISTRICT AND NEIGHBORHOOD DESIGN STRATEGIES encourage a pedestrian focus and community pride through clarity in bike and pedestrian greenway connections to activity centers, schools, parks, etc.-creating effective district and neighborhood definition and nodes. The nodes combine transit, community facilities, commercial areas, cultural and recreational amenities, information and focus. The critical district and neighborhood design strategies are summarized below (reference Figure 7 to 8):

A. Transit networks and greenways (pedestrian priority streets and bikeways) define neighborhoods and districts. Pedestrian accessible schools, commercial centers, and related park facilities become the district focus and integrate four or more neighborhoods together into a district.

B. Because of the renewed quality of the neighborhoods, renewal and densification is preferred over low density sprawl. New lower density developments will become unpopular because all future new developments must pay "development impact fees" for their proportion of greenbelt, trees and infrastructure established by the city's sustainable programs.

C. The pedestrian streets foster walking accessibility to neighborhood facilities, parks, transit stations, recycling and compost centers and, most importantly, neighborhood schools. The neighborhood school becomes an active center and its central geographic location is critical to the pedestrian priority concept.

D. Water conservation and gray water reuse programs are established throughout the city.

E. The successful resource management programs based on the three "Rs" (reduce, reuse and recycle) are integral parts of the community and their education programs. The traditional garbage service is now a community resource recovery process.

RESIDENTIAL STRATEGIES achieve increased opportunity for interaction through effective densification adjacent to community amenities and greenways. Density is an essential element of community formation and urbanity. Without reaching a reasonable density in any urban area, it is difficult to provide efficient utilization of urban resources and services in an economically and socially justifiable way. Increasing density to 45-60 dwellings per hectare creates pedestrianization and makes public transit more viable and efficient. The critical residential design strategies for densification can occur in the following ways (reference Figure 9 to 11):

A. External densification must be accomplished with a set of design guidelines which retain the traditional character of the districts and neighborhoods. Because of the limited availability of land,

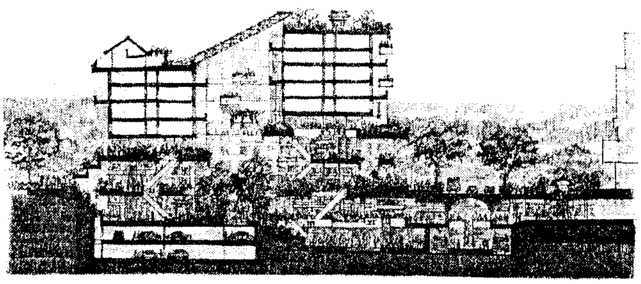


Fig. 5. City and district section emphasizing multi-use developments at transit nodes.

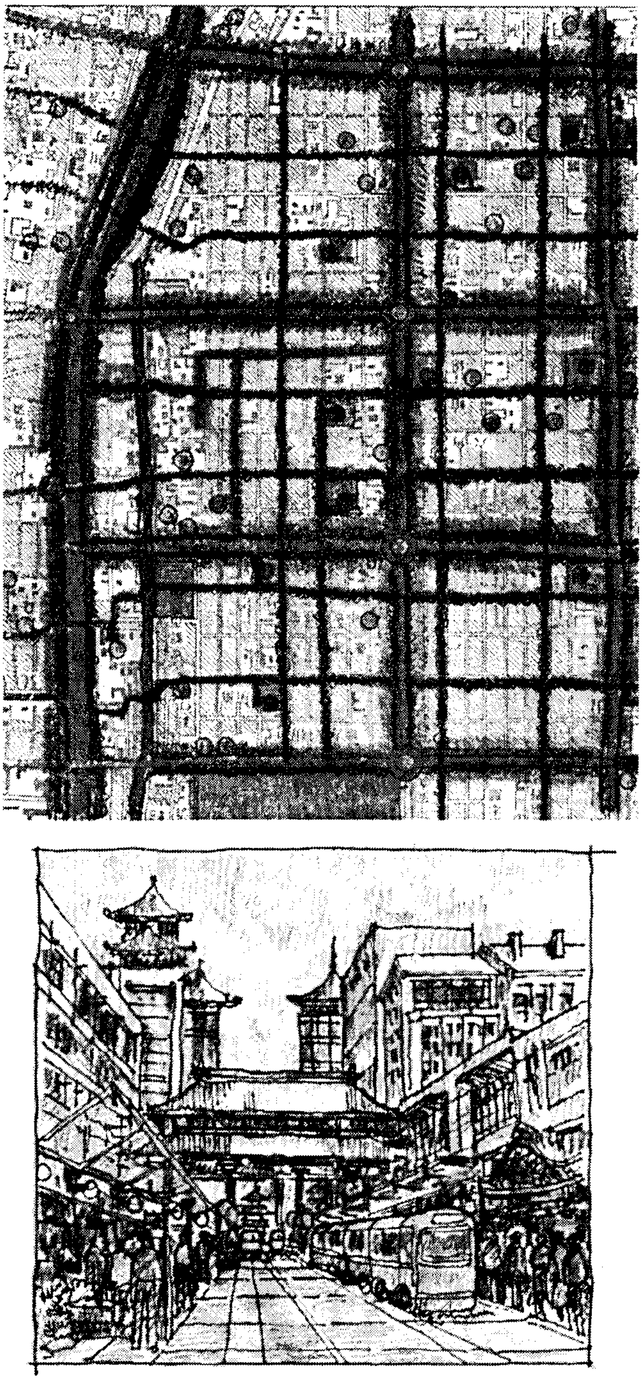


Fig. 6. Typical polygrid district-neighborhood sustainable plan and perspective of transit nodes with pedestrian overpass.

roofscapes are critical to provide views, open space, and container gardening for urban dwellings. Careful considerations are given to preserve privacy and territoriality as well as provide spaces for social interaction in the grouping of dwellings.

B. Internal unit densification can also accommodate many of the changing domestic needs and family profiles. In this situation, the dwelling can be subdivided internally or expanded to accommodate new members of the family and/or additional units. This is not a new practice. In many regions across the world, families have comfortably lived in one house for generations. Auxiliary apartments within units are very common in most countries and provide for viable alternatives to increase the efficient utilization of the residential area. This allows for an effective utilization of existing housing stock to accommodate a diversity of changing family sizes.

C. New, infill and renovated units reach a high level of land and energy conservation, optimizing the use/reuse/recycling of renewable resources of the sun, wind, water (gray and brown), food and fiber. Household cost for energy dramatically decreases due to the shift to renewable energy sources. Zoning ordinances require the residential lots to be oriented for solar access saving on the average 20% of the energy used for heating and cooling. New energy standards (quality construction, shading, higher levels of insulation, and solar benefits) conserves an additional 50% of the heating and cooling energy over past standards. The improved air quality, cooler night time temperatures, healthy material standards and natural ventilation strategies allow for almost the complete elimination of summer cooling loads from mechanical means.

D. Families enjoy the beauty of indigenous, low maintenance landscapes and permaculture. The abundance of spring rain is impounded in gardens and water cisterns. Most families install gray water systems for landscaping/gardening. All brown wastes are safely composted by the city and become a valued resource for agriculture.

E. Many of the families enjoy the development of small vegetable gardens within the residential clusters or in the greenbelt. Community greenhouses allow for extended growing seasons.

Conspectus

The sustainable regenerative proposal is based upon a comprehensive, ecological model-a critical first step in creating sustainable communities, locally and globally. The proposal first models and calculates the ecological exchanges required for sustainability. It then generates sustainable design strategies that celebrate Kyoto's fundamental policy issues, balance the ecological exchanges while providing for opportunities for renewal and creation of a truly livable city. Modeling human-environmental interchanges were found to be a powerful and useful concept, fundamental to sustainable design and planning processes.

The study and resultant sustainable design strategies will provide significant long term resource and monetary savings for each household, the city, and nation. The strategies all have a relatively short 1-7 years pay back period and can save the city billions of yen. These savings would be retained in the city instead of exported to pay for imported resources and energy. This fosters a sustainable local economy.

The implementation of this regenerative program will require collaboration between government, civic organizations and Kyoto's citizens. It is indeed wonderful that Kyoto is well on its way to define and implement a regenerative process. Kyoto, an international center for the exchange of ideas and a national treasure of Japanese culture, is taking a significant leadership role in determining a sustainable future – a future with a global vision which celebrates human and environmental health, cultural diversity, renewal while providing sustained promise for future generations of its citizens.

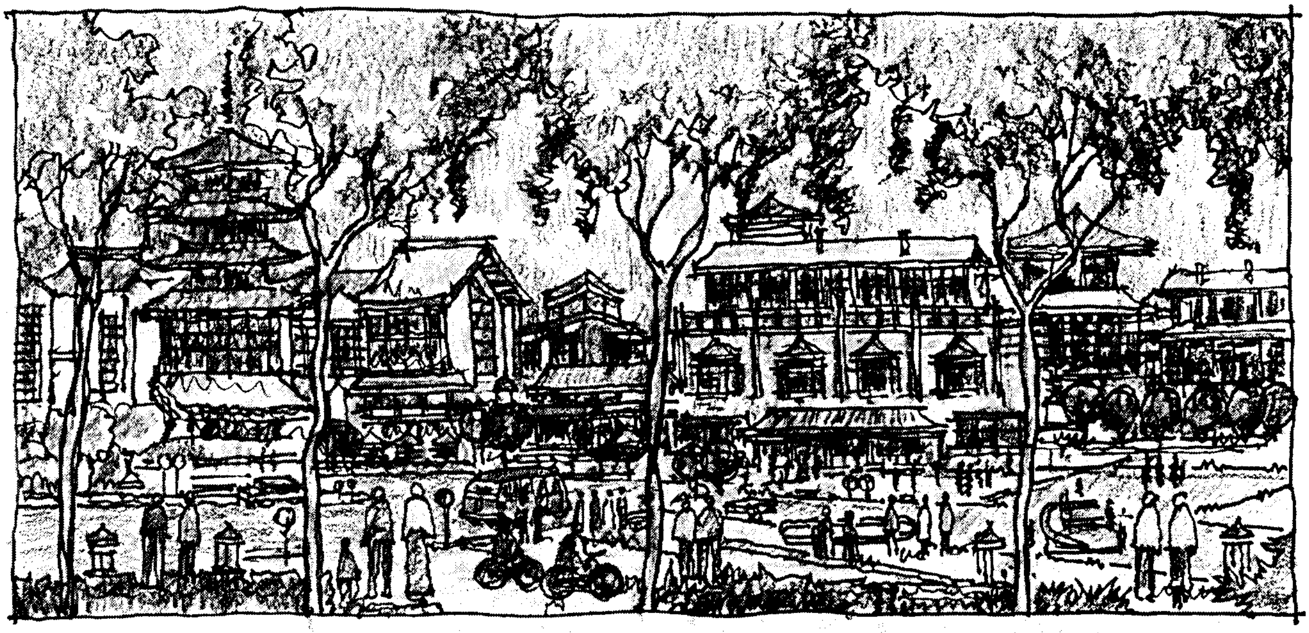


Fig. 7. Residential neighborhoods with emphasis on mixed-use developments and diversity of housing.

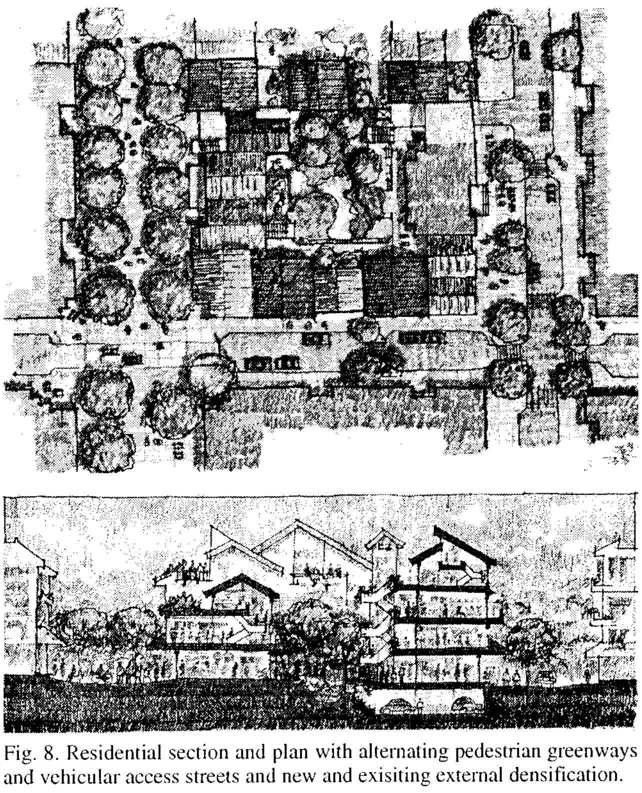


Fig. 8. Residential section and plan with alternating pedestrian greenways and vehicular access streets and new and exisiting external densification.

Addendum:
The Five Primary Ecological Variables for Modeling Sustainability

As introduced earlier, sustainability is critical to the process of recreating livable cities. The following five ecological and/or biological variables of a site system (air, water, land, energy, and human ecology) have been found useful in defining and modeling the inclusive nature of sustainability. The sustainability of each variable has been calculated and the relative values and balance points are represented in figure 2.

AIR (one can live only 2-3 minutes without oxygen). Air quality is an often overlooked, yet a critical resource to human and planetary health (reducing ozone depletion and global warming). Although air exchanges are complex, **the carbon dioxide to oxygen (CO_2–O) cycle becomes a useful technique for modeling sustainability.** Society, locally and globally, must reduce the burning of carbons and place CO_2 in balance with the oxygen producing photosynthesis. Modeling CO_2–O exchange mandates a truly green world and creates fundamental sustainable relationships between human and natural habitat. **Although Kyoto generates 1.57 tons of CO_2 per year (half of that generated per capita in Japan (Kyoto, 1997), 50% energy conservation, increased urban street trees/landscaping and a 20-25% extension of the green belt are required to reach a CO_2–O balance point.**

WATER (one can live only 2-3 days without water). Humans require approximately 10-20 liters of water per day, yet we consume on average 400-500 liters per day, depending on what societal sectors are included in the estimate. Quality water is rapidly becoming a critical resource and the competitive human-environmental demands will require careful management and conservation in the next decade. **Modeling the input and output of water resources of a site generally mandates the need for water conservation to place the H_2O exchange in balance with the amount of precipitation that falls on a site, especially in the dry seasons of summer and fall.** Most sustainable goals for communities would vary from 75 liters per person in desert climates to 125 liters in an area which receives over 0.5 meters of rainfall per year. To achieve these amounts, water conservation, indigenous landscaping and water impoundment programs are critical. The establishment of gray water systems can substantially increase the household's use of water. **Although Kyoto's annual precipitation is 1.4 meters (Kyoto, 1997), 20% conservation and water impoundment programs are needed to supplement the dry seasons. Also critical are measures to protect quality water sources in aquifers, wetlands and water systems in the green belt.**

LAND: FOOD AND FIBER (one can live only 2-3 weeks without food). The food, fiber and other material resource requirements of a site are very complex and the authors are searching for ways to model these variables. **The three R's (reduce, reuse, recycle) seem to be an approximate model for sustainability. The amount or percent of resources recycled is a useful indicators of sustainability. Total sustainable strategies would require 100%**

recycling and would eliminate disposal-today's wastes become resources to be reused/recycled. "Precycling" (selecting goods with high recycled content and/or can be recycled) is also very important in reducing consumption of virgin fibers. Also food and fiber cycles can be local or global. Studies have suggested that a food travels thousands of miles before it reaches our dinner table. Food and fiber needs to be grown locally-even in one's own garden. Sustainability is increased with local or regional self sufficiency. **Kyoto's "Ecological Footprint" (the amount of land required to support one person) has been calculated to be 2 hectares per person (Wackernagel & Rees, 1996). This is 40-60% less than most western countries. Even though this is very efficient, Kyoto's land base is some 50 times too small to be sustainable. Food and fiber resources must be imported from other regions, locally and/or globally. Sustainability would encourage the celebration of local or regional resources from sustainable or "green" markets.**

ENERGY (the primary agent in ecological systems). In vernacular environments, many generations of people have lived full lives with the use of renewable energies. Energy exchanges are fundamental to modeling sustainability and energy use is highly related to air, water and land use. Renewable energies are, for the most part, sustainable whereas nonrenewable systems are not. **Therefore, sustainability can be modeled by a site or society's percentage use of renewable energies.** Fortunately, energy conservation is a well-accepted goal of the design professions. Designing with climate, computer-aided interactive modeling of energy performance, and the use of daylight and renewable energy are critical, qualitative architectural and energy conservation issues. Also critical is continued progress in increasing auto efficiencies and reducing their use by creating compact clustered developments with pedestrian/bike and transit priorities. **This proposal recommends a goal of 50% conservation and a shift to renewable sources: 50% solar, 40% hydropower and 10% wind farms in the greenbelt and local region.** For the energy estimates, the authors were not able to determine Kyoto's energy profile and interpolated general percentages from the other development countries.

ECOLOGY: HUMAN – ENVIRONMENTAL RELATIONSHIPS (a critical and dominant indicator of society's abilities to achieve sustainability). Ecology, or more specifically **human ecology**, defines the final, but most challenging and inclusive variable to this proposed set. It, of course, includes the other four more basic environmental variables (air, water, land and energy). The authors have separated them out for clarity, to minimize human centeredness and to emphasize that these natural, invisible variables are more **biologically and ecologically** fundamental to society's ability to define, model and measure sustainable development. **How society defines and manages its humanenvironmental interactions is probably the central defining issue to this all-inclusive variable. This requires a participatory grass-roots community process and leadership from governmental and design professionals.** Literally hundreds of communities across the US (Corson, 1992) and many times more around the globe are actively pursuing sustainable planning by defining and modeling "indicators" of human-environmental interrelationships. **For Kyoto, this proposal illustrates and recommends the above 17 strategies to enhance the unique quality of the critical human and environmental aspects of this important historic city.**

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