Sustainable urban regenerative process and densification: theory and practice

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Abstract

This paper will define the theoretical premise of sustainable` design and its practice. This theory is then formulated into a sustainable planning and design process, which was used to develop the regenerative sustainable community proposal for the authors' city of residence – Pullman, Washington, USA. The proposal was awarded a **gold medal** at the UN Habitat-II Conference in Istanbul, Turkey [9]. Probably more importantly, it has increased community concerns for sustainable development. The proposal can be reviewed on our web site (www.arch.wsu.edu/sustain).

The Pullman regenerative and densification proposal stands upon the ecological modeling techniques which carefully balance on-site interchanges between the unique human and environmental systems. The amount or percentage of renewable human and environmental resources used by a development is a useful "indicator" or measurement of the degree to which sustainability is achieved. The primary ecological or biological variables used in this process were **air, water, food and fiber, energy, and human ecology**. These interchanges became indicators of sustainable development and define inherent qualities and the carrying capacity of the city. This approach allows this community (as well as others) to model, measure and program a series of design strategies for sustainable development as well as monitor the city's regenerative process. The authors have researched and documented how the selected strategies have been successfully applied in other vernacular and contemporary cities and architecture throughout the world. The resultant program and plan was an effort to revitalize the existing community, enhance its sense of place and human/social, economic, and environmental qualities. The critical integrated levels of sustainable, regenerative intervention permeates all scales of the defining qualities of this place, defined in a nested hierarchy including the **region, city, neighborhood, clusters and dwelling units**. The proposal, its theory and methodology have created a useful model and method for this city (and others) to evaluate the effectiveness of various planning and citizen initiatives as we work towards a sustainable future.

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1 A clustered, sustainable regenerative plan and densification for Pullman, Washington, USA: theory and practice

Pullman is a relatively small community of 25,000 located in the Pacific Northwestern Palouse Region of Eastern Washington. It is the size of some of the nested towns and villages in larger metropolitan areas. The regional climate of Pullman has distinct seasons with cold, wet winters and warm, dry summers. The city's economy services the region's agricultural industries and supports a major public university. As a University town, it has an extremely important leadership role in educating our future leaders (in classes and by the design of the community).

As discussed in the introduction, Pullman's sustainable community plan was based upon ecological (or "bio-logical") modeling techniques, which carefully balance **on-site** interchanges between the unique human and environmental systems of the city. These interchanges become indicators of sustainable development and define inherent qualities, carrying capacities, and the required ecological footprint of this community. In general, this approach allows communities to model, measure and program a series of design strategies for sustainable development. Also, this method allows communities to define and monitor human-environmental indicators of a regenerative process. Sustainable indicators are commonly generated and agreed upon by the community. This study predates the community generated processes and takes a more theoretical approach based upon ecological or bio-logical criteria.

This approach was derived from first establishing a working definition of sustainability. There are, of course, many definitions of sustainability. In review of the plurality of this term, the site or the human-environmental context is an important variable to most working definitions of sustainability. This emphasis is expressed in the following composite definition, which directed the Pullman regenerative study:

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, and ecology and/or those of other [off-site] sustainable systems [14,16]. Sustainability integrates natural systems with human patterns and celebrates continuity, uniqueness and place making [17].

Although the site is definable, its natural cycles are primarily invisible and transcend artificial boundaries (building, site, community, regional and global scales). Many sustainable developments strive for self-sufficiency by attempting to operate independently of external utility or energy systems. The amount or percentage of renewable resources of a site used by a development is a useful "indicator" or measurement of its sustainability.

The Pullman study models the biological variables of air, water, land, energy and human ecology as primary indicators of sustainable community development. These fundamental human-environmental exchanges of the community's "site" were found very useful in developing critical "input↔ output" modeling techniques which directs the community's regenerative

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process. This ecological method illustrates the challenging requirements for programming, measuring and achieving sustainability. These ecological variables are, of course, interrelated and form the basis for modeling a sustainable community and/or society. The selected variables/systems of the community's human and environmental interrelationships are diagrammed in Figure 1 and are further discussed in our web site.

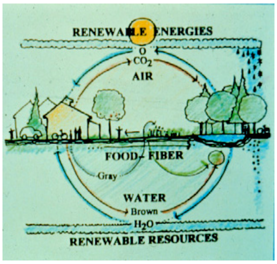

Figure 1: Ecological systems diagram.

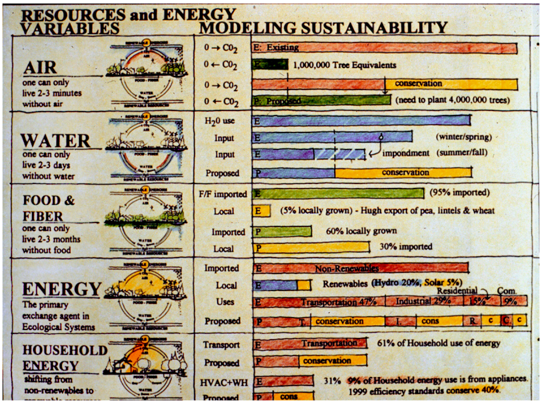

Figure 2: Analysis of the community's human-environmental systems.

In quantitative terms, the related ecological exchanges between the selected human-environmental systems of air, water, food and fiber (land) and energy for the community are also illustrated in the bar graph (Figure 2). Their relationships demonstrate the importance of modeling and measuring the selected set of indicators for sustainability. For each ecological interchange, the bar graph illustrates the relative quantities of the following:

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

The method, once used, demonstrates the interaction of each system and that 40-70% conservation is required to place each resource exchange in a sustainable balance. Also, the method conveys an invisible surprise, that air represented by $CO_2 \leftrightarrow O$ (carbon dioxide to oxygen) exchange achieved through photosynthesis is one of the most overlooked yet fundamentally critical and representative of all the systems. Driving the air exchange imbalance is the use of energy, especially the combustion of fossil fuels. Fortunately, state, national and international directives are recommending and/or mandating 50% levels of conservation (50% recycling, 50% energy conservation in buildings, etc.). Unfortunately, automobiles (and trucks), the largest consumer of air and energy, are not part of

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these recommendations. President Carter was able to enact significant efficiency standards in our automobile fleet. Unfortunately, this leadership has been repealed and progress in nurturing transportation efficiencies has been tragically reversed. Our highly subsidized, inexpensive gasoline and related politics make it next to impossible to achieve increases in conservation close to the 50% level in the foreseeable future. Truly sustainable communities will require a significant improvement in auto efficiencies and their reduced use by fostering more accessible and efficient pedestrian and transit priorities within neighborhoods and throughout the community.

The study illustrates the use of these modeling techniques and the application of the resultant sustainable design strategies for this community. Many of the selected design strategies and technologies are derived from proven sustainable principles used in vernacular and contemporary societies. By definition, vernacular developments have sustained the test of time and have celebrated substantial societal development without the use of non-renewable energies. The study demonstrates the integrated use of these modeling methods and sustainable design strategies in the revitalization of this existing community, enhancing its human, economic, social and environmental quality. A useful ecological organizing technique, "levels-of-integration," is used to carefully reanimate this community and balance these fundamental human-environmental systems. A summary of these integrated levels or scales of design regeneration (region, city, neighborhoods, site/clusters and buildings) are illustrated and summarized in the following annotated outline.

A. Regional scale 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. A green belt and water impoundment system were necessary to balance air exchanges ($O=CO_2$); water cycles (precipitation=H_2O use with conservation, impoundment and reuse of gray water); 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 (reference Figure 3).

1. The green belt and greenways moderate climate extremes, increases recreational opportunities and bio-diversity. These green programs 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. A farmers market fosters local agri-cultural produce and handicrafts.
2. Spring water runoff is impounded and retained in balancing lakes which supplements dry seasons, reduces spring flooding, filters eroded soils, improves water quality, fishing and recreation potential.
3. The increased costs of non-renewable energy create a positive shift to conservation and renewable resources. The proposed community's sustainable energy budget comes from 50% regional hydropower, 40% solar and photovoltaics and 10% wind farms in the green belt.

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Figure 3: Pullman proposed regional plan with required green belt and water retention lakes.

B. City scale strategies provide for a nested hierarchy of central places (city, districts and neighborhoods) supported by an effective infrastructure emphasizing pedestrianization and public transit. This more efficient infrastructure is expressed in community greenways and the clustering of activities, which increases pedestrian enjoyment and accessibility. The critical city design strategies are summarized below (reference Figures 3).

1 geographic . The reanimation of the historic city center is facilitated by its ideal, centralized position. The clustered restructuring of the central city and the "Main Street Program" foster incentives for economic growth which reverses its past decline, a trend experienced by most US city centers due to auto-driven suburban sprawl.

2. Design priority is 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 non-renewable energy. This is the single most important strategy in balancing the CO_2 to O cycle and improving air quality in the community.

3. State building codes increase energy conservation standards, currently 50% better than the 1985 buildings to 70% in the year 2010. Due to advancements in efficiency, the use of solar design strategies and photovoltaics, many advanced buildings can actually contribute to the shared energy grid.

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

C. District and neighborhood strategies encourage a pedestrian focus and community pride through clarity in bike and pedestrian greenways, connection to activity centers, schools, parks, etc. – creating effective neighborhood definition and nodes. The nodes combine transit, community information and focus as well as convenient recycling stations. The critical **district and neighborhood design strategies** are summarized below (reference Figures 4).

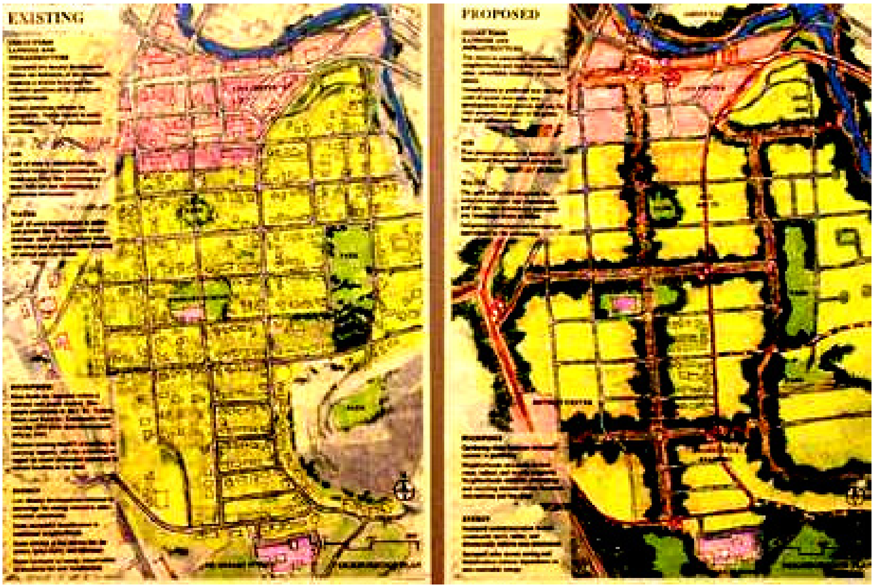

Figure 4: Pullman typical neighborhood plans (existing & proposed) showing pedestrian priority streets which connect to schools. Parks and bus stops.

1. Pedestrian priority streets with bikeways and transit networks tie the four prominent neighborhoods into two districts. Pedestrian accessible middle schools, commercial centers, and related park facilities become the district focus and integrate two pairs of neighborhoods together into districts.

2. Because of the renewed quality of the neighborhoods, densification is preferred over low density sprawl. New low-density patterns have become unpopular because all new developments must provide and pay impact fees for their proportion of greenbelt, trees and infrastructure established by the community's sustainable programs.

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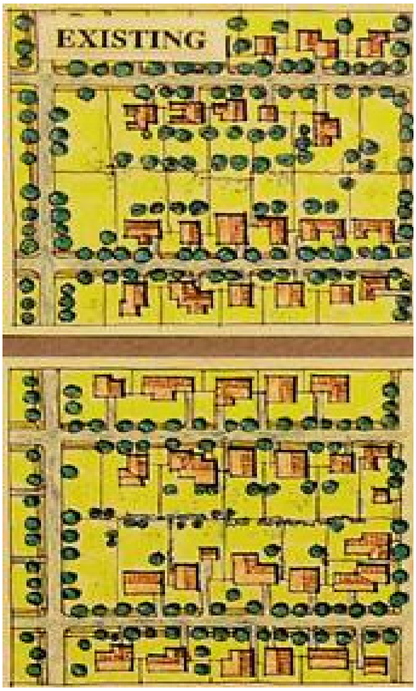
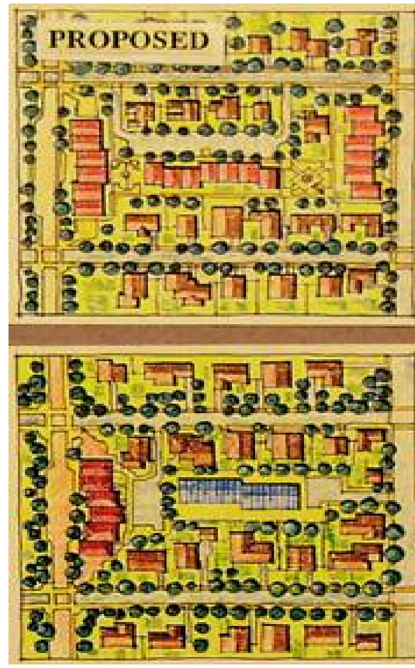
3. The green pedestrian street patterns foster walking accessibility to neighborhood facilities, parks, transit stations, recycling and compost centers and, most importantly, neighborhood schools. The neighborhood school becomes an active center and its central geographic location is critical to the pedestrian priority concept.
4. Water conservation programs and gray water reuse is implemented throughout the community.
5. The successful resource management programs based on the 3 "Rs" (reduce, reuse and recycle) are integral parts of the community. The traditional garbage service is now a community resource recovery process.

D. Clustering and Densification strategies for residential developments achieve increased opportunity for interaction through effective densification adjacent to community amenities and greenways. Density is an essential element of community urbanity and civility. Without reaching a reasonable density in any urban area, it is difficult to justify the efficient utilization of urban resources and services. The more people share community facilities, the more amenities and services can be provided in an economically and socially justifiable way. Increasing density to 12-18 dwellings per acre also creates pedestrianization and makes public transit more viable. The critical **clustering design strategies** for densification can occur in the following ways (reference Figures 5-6).

1. Peripheral infill is achieved in areas where larger side yard setbacks occur between the dwellings. In many suburban areas, setback and side yard regulations consume 30-40% of the street frontage. To increase the efficiency on such underdeveloped lots, new infill units and/or greenhouses are provided between and in front of the existing units. Each greenhouse could be commonly shared by the two families or owned by one. This arrangement increases the land use, energy efficiency and creates a well-defined internal semi-private garden space in the back of the units to be used either collectively or subdivided individually.
2. Internal and external block densification is applicable to larger blocks where the combined backyards can internally accommodate new townhouses, apartments, greenhouses and parking. Careful considerations are given to preserve family privacy and territoriality as well as provide spaces for social interaction in the clustered grouping of families (Figure 7).
3. External expanded block and communal greenhouses can also occur by utilizing wide or redundant streets between two blocks. This densification can increase efficiency and enriches the communication and social interactions between the clusters. Additional developments could be built between these blocks, including communal playgrounds, gardens and greenhouse structures.
4. Internal unit densification can also accommodate many of the changing domestic needs of the family. In this situation, the house is subdivided internally or expanded to accommodate new members of the family. This is not a new practice. In many regions across the world, families have comfortably lived in one house for generations. Also auxiliary apartments within units are very common in most countries and provide for viable alternatives to increase affordability and the efficiency of residential area.





Figures 5 & 6: Internal and infill densification plans (existing & proposed).

Figure 7: Densification and cluster perspectives.

E. Dwelling unit strategies (new, infill and renovated) 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. “Design Guidelines for Sustainable and Affordable Residential Developments” can be

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found on our web site (and [4,10]). The critical **dwelling unit design strategies** are as follows (reference Figures 8):

1. Household cost for energy dramatically decreases due to the shift to renewable energy sources and the following conservation measures:

a. 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.

b. New state energy standards (quality construction, higher levels of insulation, and solar benefits) conserves an additional 50-70% of the heating and cooling energy over 1985 standards.

c. The improved air quality, cool nighttime temperatures, healthy material standards and natural ventilation strategies allow for almost the complete elimination of summer cooling loads.

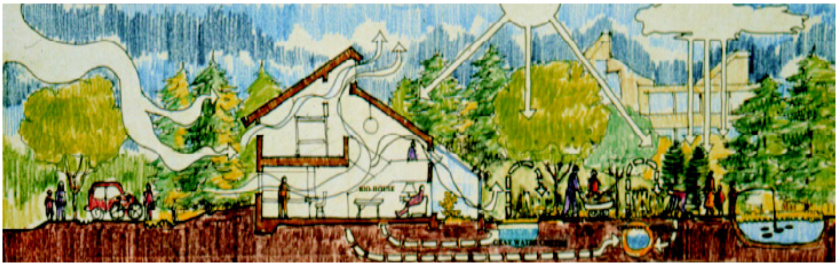

Figure 8: Typical sustainable design strategies for the dwelling unit.

2. 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.

3. Many of the families enjoy the development of small vegetable gardens adjacent to the home, within the residential clusters or in the greenbelt. Greenhouses allow for extended growing seasons.

The study concludes with a cost analysis of these sustainable design strategies, measuring the extent of the resource and monetary savings for each household, the community, state and nation. The strategies all have a relatively short 1-7 year's payback period and can save the community millions of US dollars (the state and nation billions). These savings would be retained in the community instead of exported to pay for imported resources and energy. This fosters a sustainable local economy.

2 Conclusion

The community program is based upon a holistic, ecological model – a critical first step in creating sustainable communities, locally and globally. Modeling human-environmental interchanges were found to be a powerful and useful

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concept, fundamental to sustainable design and planning processes. The implementation of this regenerative and densification programs will require collaboration between government, civic organizations and private individuals. Pullman was in the process of revising its comprehensive plan. This proposal has been presented numerous times to university and city administration and local community groups. Also, the two land grant universities (The University of Idaho – 8 miles to the east in Moscow, Idaho, and Washington State University in Pullman) are forming faculty groups and resource collaborative based upon sustainability. The future of that "paradise called the Palouse" looks promising. This process is being enhanced by grassroots efforts, demonstration projects and presentations, and lobbying of governmental and community leaders. The local universities are excellent resources for conducting research and education programs.

Although this methodology is applied to a relatively small community in a rural setting, it is transferable to larger urban places, which are generally composed of sub-units similar to this community. The proposed model is inherently a powerful research, educational and marketing tool for sustainable community planning and development. It can be used by any city as a guide for developing a comprehensive and sustainable urban regeneration program. Specific policies and strategies will vary with local conditions, but the methods for demonstrating human-environmental interchanges and benefits are universally applicable.

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