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Sustainable Urban Forms

Their Typologies, Models, and Concepts

Yosef Rafeq Jabareen

Abstract

This article identifies sustainable urban forms and their design concepts. In addition, it addresses the question of whether certain urban forms contribute more than others to sustainability. A thematic analysis has been used to cope with the vast body of sustainable development and environmental planning literature. The analysis identifies seven design concepts related to sustainable urban forms: compactness, sustainable transport, density, mixed land uses, diversity, passive solar design, and greening. Moreover, it identifies four types of sustainable urban forms: the neotraditional development, the urban containment, the compact city, and the eco-city. Finally, this article proposes a Matrix of Sustainable Urban Form to help planners in assessing the contribution of different urban forms to sustainability.

Keywords: *compact city; eco-city; design; neotraditional development; planning; transportation; urban form; urban containment*

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The form of the contemporary city has been perceived as a source of environmental problems (Alberti et al. 2003; Beatley and Manning 1997; U.S. Environmental Protection Agency [EPA] 2001; Haughton 1999, 69; Hildebrand 1999b, 16; Newman and Kenworthy 1989). The EPA (2001) concludes in *Our Built and Natural Environments* that the urban form directly affects habitat, ecosystems, endangered species, and water quality through land consumption, habitat fragmentation, and replacement of natural cover with impervious surfaces. In addition, urban form affects travel behavior, which, in turn, affects air quality; premature loss of farmland, wetlands, and open space; soil pollution and contamination; global climate; and noise (Cervero 1998, 43-48). Moreover, growing evidence from around the world indicates that, owing to our excessive use of fossil fuels, especially in affluent countries, greenhouse gas concentrations are accumulating at an alarming rate. Prospects for the future are dire indeed, unless we act collectively to alter our energy-dependent lifestyles. Urgent changes are needed not only in our behavior but also in the design of the built form.

The emergence of “sustainable development” as a popular concept (see Jabareen 2004) has revived discussion about the form of cities. Undoubtedly, it has motivated and provoked scholars and practitioners in different disciplines to seek forms for human settlements that will meet the requirements of sustainability and enable built environments to function in a more constructive way than at present. The concept of sustainable development has given a major stimulus to the question of the contribution that certain urban forms might make to lower energy consumption and lower pollution levels (U.K. Department of the Environment [DoE] 1996; Breheny 1992a, 138).

This challenge has induced scholars, planners, local and international NGOs, civil societies, and governments to propose supposedly new frameworks for the redesigning and restructuring of urban places to achieve sustainability. These approaches have been addressed on different spatial levels: (1) *the regional and metropolitan levels*, such as the Bio-Region approach (see Forman 1997; Wheeler 2000); (2) *the city level* (e.g., Girardet 1999; Nijkamp and Perrels 1994; Gibbs, Longhurst, and Braithwaite 1998; Roseland 1997; Engwicht 1992; OECD 1995; Jenks, Burton, and Williams 1996); (3) *the community level* (e.g., Nozick 1992; Paulson 1997; Corbett and Corbett 2000; Rudin and Falk 1999; Van der Ryn and Calthorpe 1991); and (4) *the building*

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level (e.g., Roelofs 1999; Edwards and Turrent 2000; Boonstra 2000; Woolley, Kimmins, and Harrison 1997).

A critical review of these approaches demonstrates a lack of agreement about the most desirable urban form in the context of sustainability (see Williams, Burton, and Jenks 2000, 347; Hildebrand 1999a; Tomita et al. 2003, 17). Moreover, there is no common conceptual framework that allows us to compare these approaches, planning propositions, and policies. For example, there is a lack of theory that helps us to evaluate whether a given urban form contributes to sustainability or to compare different forms according to their contribution to the sustainable development objectives and agenda. Therefore, this article seeks to answer the following questions: What are the distinctive urban forms proposed by each of these approaches? And what are the design concepts and principles that these forms share? In addition, the article aims to offer a conceptual framework for assessing the sustainability of urban forms.

The remainder of this article consists of five sections. The second section focuses on the methodology of the study and its parts. The study applies thematic analysis, which is an appropriate methodology when analyzing a large body of interdisciplinary texts. In addition, it presents the operational aspects of urban form to examine it more accurately. The third section identifies and describes the design concepts of sustainable urban forms. The fourth section discusses the specific sustainable urban forms that appear in the literature. The fifth section offers a conceptual framework for assessing the sustainability of urban forms. The final section draws some conclusions and suggests several issues for future research.

► Method

Form is not easy to define; therefore, it is useful to operationalize the term in order to apply it in this study. Generally, urban form is a composite of characteristics related to land use patterns, transportation system, and urban design (Handy 1996, 152-53). Kevin Lynch (1981, 47) defines urban form as “the spatial pattern of the large, inert, permanent physical objects in a city.” Form is a result of aggregations of more or less repetitive elements. Urban form, then, is a result of the bringing together of many elements-concepts: the urban pattern. Urban patterns are made up largely of a limited number of relatively undifferentiated types of elements that repeat and combine. Hence, these patterns have strong similarities and can be grouped conceptually into what are called concepts (Lozano 1990, 55). Specifically, elements of concepts might be street patterns, block size and form, street design, typical lot configuration, layout of parks and public spaces, and so on.

This article assumes that there are concepts that repeat themselves and compose distinct urban sustainable forms.

Therefore, the article uses qualitative methods to identify these forms and their design concepts (design concepts) and, eventually, to identify the concepts behind them.

In a broad sense, qualitative studies ultimately aim to describe and explain a pattern of relationships, a process that requires a set of conceptually specified categories (Mishler 1990). Miles and Huberman (1994) suggest a set of qualitative “tactics” that might help in generating meanings from different texts. Following them, a thematic analysis has been designed for identifying the forms and their design concepts and for conceptualizing the theoretical base behind these forms and concepts. Thematic analysis is an inductive analytical technique that involves discovering patterns, themes, and concepts in the data that includes planning and multidisciplinary literature.

The main steps of this study’s methodology are as follows:

1. Review of planning, design, and other multidisciplinary literature that is related to sustainable development. The aim is to deconstruct (“take apart”) a multidisciplinary text related to urban sustainable form. The outcomes of this process are numerous themes, “design concepts” in this case, that are related to urban form.
2. Pattern recognition—“the ability to see patterns in seemingly random information” (Boyatzis 1998, 7). The aim is to note major patterns and concepts within the results of the first step. This second step looks for similarities or patterns within the sample and codes the results by concepts.
3. Identifying urban forms—to recognize specific and distinctive urban forms.
4. Conceptualization—to find theoretical relationships among the identified concepts and urban forms.

► Design Concepts of Sustainable Urban Form

The thematic analysis has identified seven concepts—repeated and significant themes of urban form.

1. Compactness

Compactness of the built environment is a widely acceptable strategy through which more sustainable urban forms might be achieved. Compactness also refers to urban contiguity (and connectivity), which suggests that future urban development should take place adjacent to existing urban structures (Wheeler 2002). When the concept is applied to existing rather than new urban fabric, it refers to the containment of further sprawl, rather than the reduction of the present sprawl (Hagan 2000). Compactness of urban space can minimize transport of energy, water, materials, products, and people (Elkin, McLaren, and Hillman 1991).

Intensification, a major strategy for achieving compactness, uses urban land more efficiently by increasing the density of development and activity. The intensification of the

built form includes development of previously undeveloped urban land, redevelopment of existing buildings or previously developed sites, subdivisions and conversions, and additions and extensions (Jenks 2000, 243).

Four major themes are evident in current debates on compactness as an important strategy for achieving desirable urban forms (Williams, Burton, and Jenks 2000; Pratt and Larkham 1996, 279). The first, probably the longest established and most common, is that a contained and compact city has a corollary of rural protection (McLaren 1992). The second theme is related to the promotion of quality of life, including social interactions and ready access to services and facilities. The third is the reduction of energy consumption by providing building densities capable of supporting district heating or combined heat and power systems; and the fourth is the reduction of greenhouse gas emissions by minimizing the number and length of trips by modes of transport harmful to the environment.

For many planners and scholars, compactness is the crucial typology to be implemented to achieve sustainability. For example, Dumreicher et al. (2000) argue that a sustainable city should be compact, dense, diverse, and highly integrated. They ask for an urban form that is easily walkable, small enough to eliminate even the desire for a private automobile, yet large enough to provide the variety of opportunities and services that constitute a rich urban life. Sustainability for them “is a local, informed, participatory, balance-seeking process, operating within a Sustainable Area Budget (SAB), exporting no imbalances beyond its territory or into the future, expanding the spaces for possibilities to flourish” (p. 360). Compactness goes hand in hand with the goal of livability and works to prevent commuting, one of the most wasteful and frustrating aspects of city living today (Sherlock 1990, 53).

2. Sustainable Transport

Transport is arguably the single biggest issue for environmental debates relating to urban form (Jenks, Burton, and Williams 1996, 171). The form of our cities reflects, to a large extent, the transport technologies that were dominant at different stages of their development (Barrett 1996, 171). Interestingly, for Clercq and Bertolini (2003, 38), “sustainability is defined as diminishing both mobility and the negative of traffic.” Elkin, McLaren, and Hillman (1991, 12) argue that sustainable urban form must be a form and scale appropriate to walking, cycling, and efficient public transport and must have a compactness that encourages social interaction. It must enable access to the facilities and services of the city while minimizing the resulting external costs.

“Sustainable transportation” is defined as “transportation services that reflect the full social and environmental costs of

their provision; that respect carrying capacity; and that balance the needs for mobility and safety with the needs for access, environmental quality, and neighborhood livability” (Jordan and Horan 1997, 72). For Duncan and Hartman (1996), a sustainable urban transportation system limits emissions and waste to within the area’s ability to absorb; is powered by renewable energy sources, recycles its components, and minimizes the use of land; provides equitable access for people and their goods and helps achieve a healthy and desirable quality of life in each generation; and is financially affordable, operates at maximum efficiency, and supports a vibrant economy.

Policies for sustainable urban development should, therefore, include measures to reduce the need for movement and to provide favorable conditions for energy-efficient and environmentally friendly forms of transport. Land use planning has a key role to play in the attainment of these objectives. It is assumed that when the physical separation of activities is smaller, travel needs are likely to be lower and easily met by walking, cycling, and environmentally friendly transport.

Some scholars argue that we know fairly little about how urban form shapes and affects travel behavior. Boarnet and Crane (2001) suggest that we lower our expectations about the travel-reduction benefits of urban design and expand our understanding of the effects of other transportation policies.

The influential literatures of neotraditional planning and the “new urbanism” often argue that car use will decline in neighborhoods designed with more pedestrian-friendly features, such as a connected street layout, more mixed use, high enough densities to more closely group some commercial and residential development, traffic calming, and so on. Crane and Crepeau (1998, 18) assert that “many times, these transportation benefits have been advertised as facts rather than hypotheses, and have even been utilized or at least recommended as tools for decreasing the negative environmental impacts associated with car travel.” Robert Cervero (2003, 18) argues that “integrated transport and urbanism—despite the many barriers that must be overcome—is likely to prevail as America’s dominant paradigm of community-building in the twenty-first century.” In addition, he claims that we still have a lot to learn about how the designs of neighborhoods, communities, and regions shape travel behavior.

Restructuring of the urban and metropolitan transportation system can help conserve energy in several ways. In *The Transit Metropolis*, Robert Cervero (1998, 46) argues that “compact, transit-oriented development shortens trips, thus encouraging non-motorized travel. And conversion of low-occupancy auto trips to mass transit cuts down per capita fuel consumption.”

Newman and Kenworthy (1989) found a strong inverse relationship between urban density and energy consumption for transport. Some scholars, however, argue that there is no advantage of one form of development relative to another.

Rickaby, Steadman, and Barrett (1992) analyzed a representative sample of twenty English towns with populations between 50,000 and 150,000 residents. For each town, data were collected describing the pattern of land use and the extent and form of development. Ultimately, the study suggests that within towns of this size quite radical variations in policy toward the location of new development may have only slight implications for the use of fuel in passenger transport (p. 195).

3. Density

Density is a critical typology in determining sustainable urban forms. It is the ratio of people or dwelling units to land area. The relationship between density and urban character is also based on the concept of viable thresholds: at certain densities (thresholds), the number of people within a given area becomes sufficient to generate the interactions needed to make urban functions or activities viable.

In a wider sense, sustainable cities are a matter of density (Carl 2000). Density and dwelling type affect sustainability through differences in the consumption of energy; materials; and land for housing, transportation, and urban infrastructure (Walker and Rees 1997). High density and integrated land use not only conserve resources but provide for compactness that encourages social interaction.

Newman and Kenworthy (1989, 33) conclude that some policies can save significant amounts of energy, mainly by “increasing the urban density; strengthening the city center; extending the proportion of a city that has inner-area land use; providing a good transit option; and restraining the provision of automobile infrastructure.” They advocate a policy of new mass rail transit systems for the “inefficient” cities.

Density is the single most important factor associated with transit use (Transportation Research Board of the National Academy 1996). As density increases, automobile ownership declines, and automobile travel—as measured by gasoline consumption or per capita vehicle miles of travel (VMT)—also decreases. Similarly, transit use increases with density. In a sample of eleven large metropolitan areas, the density of nearby housing strongly influenced commuter mode choices. Holding constant the mix of land uses, residents of higher-density areas were more likely to commute by transit, walking, bicycling, or combinations thereof, and less likely to drive, than people who live in lower-density areas (Transportation Research Board of the National Academy 1996).

There is an inherent conflict between lower densities and a good transport system, where lower densities encourage car use. Freeman (1984) blames planners, architects, and local governments for reducing high urban density as well as for the low densities of suburbs. These densities make facilities difficult to provide without imposing a degree of car travel, which is environmentally damaging.

Some scholars, however, call for dispersed living patterns with reduced density. Clark, Burall, and Roberts (1993, 146) have argued that sustainable development implies a “self-support economy” and requires “more land for outbuildings and outdoor activities . . . and a general reduction in net residential densities.” Similarly, Robertson (1990) has argued in favor of a decentralized future based upon a return to the countryside and a revival of rural values.

4. Mixed Land Uses

There is a general consensus among planners and scholars that mixed land use has an important role in achieving sustainable urban form. Mixed-use or heterogeneous zoning allows compatible land uses to locate in close proximity to one another and thereby decrease the travel distances between activities (Parker 1994). Mixed land use indicates the diversity of functional land uses such as residential, commercial, industrial, institutional, and those related to transportation. Reducing the need for travel is on the agenda of achieving sustainable urban form, and mixed land use has a prominent role in achieving it. Mixed land use reduces the probability of using a car for commuting, shopping, and leisure trips, since jobs, shops, and leisure facilities are located nearby (Alberti 2000; Van and Senior 2000). Mixing uses ensures that many services are within a reasonable distance, thus encouraging cycling or walking (Thorne and Filmer-Sankey 2003). In addition, mixed use of space can renew life in many parts of the city and in turn enhance security in public spaces for disadvantaged groups (Elkin, McLaren, and Hillman 1991, 22).

For the past several decades, urban planning has been “unmixing” cities by the use of rigid zoning that separates single land uses into differently colored parts of the city plan. The result is a city with less diversity in local areas and more traffic, as well as reduced safety and diminished attractiveness of local streets (Newman 1997). For a sustainable urban form, mixed uses should be encouraged in cities, and zoning discouraged (see Breheny 1992b, 22).

A rapidly expanding literature continues to investigate the potential for causal links between urban design and travel behavior, yet there remain many gaps and considerable disagreement (Crane 1999). The motivating question is how to design built environments to reduce automobile use. The aim is to reduce air pollution and traffic congestion, as well as to stimulate the interaction of residents, by increasing pedestrian traffic and generally improving neighborhood charm. Numerous studies report that higher densities, mixed land uses, more open circulation patterns, and pedestrian-“friendly” environments are all associated with less car travel. Others argue that these results are difficult either to confirm or to interpret (Rutherford, McCormack, and Wilkinson 1996).

Several studies have found that transportation-related benefits of mixed land use include a decrease in vehicle trip generation rates and the number of vehicle hours traveled and higher levels of pedestrian travel (see Institute of Transportation Engineers 1989; Ewing, Haliyur, and Page 1994). However, some urge caution because the issue is complex. Frank (2000, 12) argues that empirical research regarding the relationship between mixed land uses and travel behavior has been limited by the relative complexity of measurement, requirements for parcel or area-level data, and the difficulty in accurately translating findings into public policy. Moreover, skeptics cite a lack of control for nonurban form factors, including household income and the availability of alternative modes of transportation (Parker 1994; JHK & Associates 1995).

5. Diversity

Diversity of activity is essential to the sustainability of cities. Jane Jacobs (1961) popularized the diversity dimension, subsequently adopted and widely accepted by many planning approaches, such as new urbanism, smart growth, and sustainable development. Lack of concentrated diversity can put people into automobiles for almost all their needs. Jacobs writes, "In dense, diversified city areas, people still walk, an activity that is impractical in the suburbs and in most grey areas. The more intensely various and close-grained the diversity in an area, the more walking. Even people who come into a lively, diverse area from outside, whether by car or by public transportation, walk when they get there" (p. 230). For Jacobs, diversity is vital; without it, the urban system declines as a living place and a place to live.

There are some similarities between diversity and mixed land uses; however, diversity is "a multidimensional phenomenon" (Turner, Robyne, and Murray 2001, 320) that promotes further desirable urban features, including greater variety of housing types, building densities, household sizes, ages, cultures, and incomes (see the Congress for the New Urbanism and U.S. Department of Housing and Urban Development 2000). Thus, diversity represents the social and cultural context of the urban form.

Diverse development contains a mixture of land uses, building and housing types, architectural styles, and rents. "If development is not diverse, then homogeneity of built forms often produces unattractive, monotonous urban landscapes, a lack of housing for all income groups, class and racial segregation, and job-housing imbalances that lead to increased driving, congestion, and air pollution" (Wheeler 2002, 328).

6. Passive Solar Design

Passive solar design is central to achieving a sustainable urban form. Generally, the idea of this design is to reduce the

demand for energy and to provide the best use of passive energy in sustainable ways through specific design measures. This design affects the form of the built environment through, for example, the orientation of buildings and urban densities (Thomas 2003). It is assumed that design, siting, orientation, layout, and landscaping can make the optimum use of solar gain and microclimatic conditions to minimize the need for space heating or cooling of buildings by conventional energy sources (Owens 1992).

The urban area, described as the "urban microclimate," has a different climate from the countryside (Barry and Chorley 1998). Compared to open country, built urban sites have larger areas of exposed surfaces per unit area of ground cover. Because of the larger area, potentially more solar radiation can be collected on a built urban site than on a flat, open terrain, especially in winter. In the city, a surface's exposure to the sun at any given time is largely determined by the built form, as well as the street widths and orientation. Yannas (1998, 43) summarizes some design parameters for improving urban microclimate and achieving environmentally sustainable cities: (1) *built form*—density and type, to influence airflow, view of sun and sky, and exposed surface area; (2) *street canyon*—width-to-height ratio and orientation, to influence warming and cooling processes, thermal and visual comfort conditions, and pollution dispersal; (3) *building design*—to influence building heat gains and losses, albedo and thermal capacity of external surfaces, and use of transitional spaces; (4) *urban materials and surfaces finish*—to influence absorption, heat storage, and emissivity; (5) *vegetation and bodies of water*—to influence evaporative cooling processes on building surfaces and/or in open spaces; and (6) *traffic*—reduction, diversion, and rerouting to reduce air and noise pollution and heat discharge.

Interaction between energy systems and urban structure takes place at all spatial scales from the regional, city, and neighborhood to the individual building (Owens 1992, 81-82). So far, sustainable forms have had a crucial role in the reduction of energy usage. Edwards (1996, xv) argues that "architects have a larger share of responsibility for the world's consumption of fossil fuel and global warming gas production than any other professional group" and, furthermore, states that half of all energy used in the United Kingdom, and in the world at large, is related to buildings. Plainly, ecological design and mixed land use planning policies promote energy efficiency.

7. Greening

Greening of the city, or *green urbanism*, appears to be an important design concept for the sustainable urban form. Green space has the ability to contribute positively to some key agendas in urban areas, including sustainability (Swanwick, Dunnett, and Woolley 2003). Greening seeks to embrace

nature as integral to the city itself and to bring nature into the life of city dwellers through a diversity of open landscapes (Elkin, McLaren, and Hillman 1991, 116). Greening of the city makes urban and suburban places appealing and pleasant (Van der Ryn and Cowan 1995; Nassauer 1997) and more sustainable (Dumreicher et al. 2000).

There are many other benefits from greening urban spaces (Swanwick, Dunnett, and Woolley 2003; Beer, Delshammar, and Schildwacht 2003): (1) contributions to maintenance of biodiversity through the conservation and enhancement of the distinctive range of urban habitats (Gilbert 1991; Kendle and Forbes 1997; Niemela 1999); (2) amelioration of the physical urban environment by reducing pollution, moderating the extremes of the urban climate, and contributing to cost-effective sustainable urban drainage systems (Von Stulpnagel, Horbert, and Sukopp 1990; Plummer and Shewan 1992; Hough 1995); (3) contributions to sustainable development to improve the image of the urban area; (4) improvement of the urban image and quality of life (DoE 1996); and (5) increasing the economic attractiveness of a city and fostering community pride (Beer, Delshammar, and Schildwacht 2003). Greening also has health benefits (Ulrich 1999) and an educational function as a symbol or representation of nature (Forman 2002). Finally, greening aims also to preserve and enhance the ecological diversity of the environment of urban places.

In *Green Urbanism*, Timothy Beatley (2000) emphasizes the important roles of cities and positive urbanism in shaping more sustainable places, communities, and lifestyles. He contends that our old approaches to urbanism are incomplete and must be expanded to incorporate more ecologically responsible forms of living and settlement. In Beatley's view, a city exemplifies green urbanism if it (1) strives to live within its ecological limits, (2) is designed to function in ways analogous to nature, (3) strives to achieve a circular rather than a linear metabolism, (4) strives toward local and regional self-sufficiency, (5) facilitates more sustainable lifestyles, and (6) emphasizes a high quality of neighborhood and community life (pp. 6-8).

► Urban Forms

This study has identified seven design concepts that are related to sustainable urban forms. The literature analysis shows that different combinations of these concepts produce a number of distinguished urban forms. Eventually, the study has identified four models of sustainable urban forms.

1. Neotraditional Development

Traditional built environments have inspired planners and architects to seek better urban forms based on some of

their physical qualities, in a movement called "neotraditional town planning" (Nasar 2003, 58). The new urbanism is the best known among the neotraditional approaches to planning. New urbanism advocates design-based strategies based on traditional urban forms to help arrest suburban sprawl and inner-city decline and to build and rebuild neighborhoods and cities. Charles Bohl (2000) argues that new urbanism is simply an approach to planning and design that draws on historical precedents for ways to blend different combinations of housing types in the form of neighborhoods, rather than superblocks, suburbs, or projects.

New urbanists believe that their residential design features can satisfy residents, encourage local walking and use, support pleasing neighborhood contacts, and bolster a strong sense of community, while increasing residential densities beyond the suburban norm (Leccese and McCormick 2000). Keys to new urbanist and neotraditional residential designs include mixing housing types for a wide range of incomes and household structures, providing for greater density and human contact in the neighborhood and reinforcing human presence by taming the ubiquitous automobile (Audirac and Shermyen 1994; Leccese and McCormick 2000). New urbanists believe that front porches, along with narrow streets, back-alley garages, shallow setbacks, and street trees may promote small town neighborliness characteristic of the 1920s. Wheeler (2002) argues that nineteenth-century neighborhoods with diverse building types and land uses are today among the most vibrant, attractive, and popular districts. He concludes that zoning was a major institutional force working against diversity of urban form.

Neotraditional development, or the new urbanism, emphasizes certain concepts of sustainable urban form. In *transport*, neotraditional development suggests pedestrian orientation and walkable villages. In *density*, it promotes higher residential densities than typical suburbs. In *mixed land uses*, it suggests a mix of residential, commercial, and civic uses. Accordingly, the ideal neotraditional town would be self-contained, tightly clustered, walkable, and patterned on the American small town of pre-World War II. It would have mixed land uses, as well as higher densities; street patterns that allow drivers and pedestrians a variety of path options (encouraging people to walk from place to place); distinct traditional architectural characters; and the encouragement of street life through such features as narrower streets, front porches, and public open space (Nasar 2003; Audirac and Shermyen 1994; Calthorpe 1993; Duany and Plater-Zyberk 1992; Fulton 1992; MacBurnie 1992; Lerner-Lam et al. 1992; Sutro 1990).

Another type of development that is also based on the neotraditional form of development is transit-oriented development (TOD). Various other terms have surfaced over the years to convey the idea of TOD, such as "transit village," "transit-supportive development," and "transit-friendly design,"

but TOD is the most widely used term. Most definitions of TOD share several common elements: mixed-use development, development that is close to and well served by transit, and development that is conducive to transit riding (Transportation Research Board of the National Academy 2002, 5-7). Boarnet and Crane (1997) define TOD as a developing or intensifying of residential land use near rail stations. For Still (2002), it means a mixed-use community that encourages people to live near transit services and to decrease their dependence on driving.

The *transit village*, one of the TOD applications, is “a compact, mixed-use community, centered around a transit station that, by design, invites residents, workers, and shoppers to drive their cars less and ride mass transit more. . . . The centerpiece of the transit village is the transit station and the civic and public spaces that surround it” (Bernick and Cervero 1997, 5).

The *urban village* is another model of neotraditional development that appeared first in the early 1980s in the United States and in the late 1980s in the United Kingdom (see Aldous 1992). The popular idea of sustainable development in the 1990s contributed to the formation of the goals of the urban village. According to the Urban Villages Forum, an urban village is a settlement created on a greenfield or brownfield site, or out of an existing development. Its features are high density; mixed use; mix of housing tenures, ages, and social groups; high quality; and being based on walking (Aldous 1992). Citing examples from the United States and Canada, Kenworthy (1991) states that the urban village is a trend that attempts to respond to an emptiness in community life and fulfills deeply felt needs for convenience, efficiency, beauty, and connection to a larger portion of humanity. Other reasons for the trends toward the urban village include factors such as traffic congestion, pollution, infrastructure costs, and quality of life.

Douglas Kelbaugh (1997) suggests that urban villages and zoning reforms are good strategies for existing cities and suburbs. He believes that “Seattle’s urban villages make sense” for the following reasons: they are an effective way for the city to take its fair share of regional growth; they are economical since they use existing institutions; and they are walkable, neighborly, transit-friendly, and sustainable, offering a lively and rich environment (pp. 121-27).

Some scholars argue that there is a gap between the rhetoric of new urbanism and its reality in practice. Beatley (2000, 65) asserts that designs of new urbanism are higher in density, more compact, and more walkable than suburban places. But in many ways, their reality does not match their rhetorical aspirations. The densities are often not much higher than conventional suburban development, and they often lack the transit, mixed uses, and other ingredients that could make them fundamentally more sustainable. Beatley criticizes new urbanism projects for rarely being concerned with

reducing ecological impacts or promoting more ecologically sustainable lifestyles. Thus, “what we need today are cities that reflect a different new urbanism, a new urbanism that is dramatically more ecological in design and functioning and that has ecological limits at its core” (p. 5).

Alex Kreiger (1998, 74) argues that, to date, new urbanism projects have helped produce more subdivisions than towns; densities too low to support much mixed use, much less to support public transportation; relatively homogeneous demographic enclaves, not “rainbow coalitions”; a new, attractive, and desirable form of planned unit development, but not yet substantial infill; a new wave of determinism, implying that community can be ensured through design; and a perpetuation of the myth of being able to create and sustain urban environments amidst pastoral settings. Kreiger contends that such projects, with their evocations, provide a new legitimation of low-density, peripherally located, home-dominated real estate development.

2. Urban Containment

In the early 1900s, most urban areas were compact and urban populations in the United States were concentrated within cities, but by the 1960s, this pattern began to change (EPA 2001, 4-19). During the 1970s and 1980s, more than 95 percent of U.S. population growth took place in suburban areas outside cities (Gillham 2002). In the United States today, more people live and work in suburbs than in cities. Thus, “sprawl,” which is characterized as a chaotic mess of low-density housing and commercial strip development created by and dependent on extensive automobile use, has emerged as the dominant development pattern throughout much of the United States (Ewing 1997; Gillham 2002). The scattered, low-density development characteristic of sprawl occupies far more land than do multistoried and higher-density urban centers and has significant effects on the land and its resources. The impacts of increased urbanization and sprawl development are also apparent in many regions worldwide (Vitousek et al. 1997; Alberti et al. 2003).

Recognition of the costs of sprawl has prompted policy makers in the United States, other developed countries, and a few developing countries to create urban containment policies that impose geographical constraints on urban growth to contain sprawl and restrain urban growth. At its heart, urban containment prevents the outward expansion of the urban field and forces the development market to look inward. It seeks to employ an array of public policy tools to manipulate “push” and “pull” factors so that the metropolitan area will take a particular and desirable geographical form. The goals of containment policy vary widely and include preservation of natural land, as well as farmland and resource extraction land, whose economic value will not be able to compete with urban

development; cost-efficient construction and use of urban infrastructure; reinvestment in existing urbanized areas that might otherwise be neglected; and the creation of higher-density land use patterns that encourage a mix of uses and patronage of public transit, leading to a more efficient utilization of land in urbanized areas (Pendall, Martin, and Fulton 2004).

Urban containment policies include the enactment of regulatory urban growth boundaries, limiting utility extensions to outlying areas, delineation and acquisition of greenbelts, controls on pattern and density of development, restricting new residential development in agricultural areas, pacing new development to match development of new infrastructure, restricting the numbers of new residential permits issued, land preservation programs, tax incentives, and a variety of other measures (Porter 1997; Razin 1998; Tjallingii 2000; Gillham 2002; Nelson et al. 2004). In general, urban containment policies seek to use at least three different types of tools to shape metropolitan growth. *Greenbelts* and *urban growth boundaries* are used to affect the “push” factors, while *urban service areas* are used to affect the “pull” factors.

Greenbelts are a spatial technique for containment. A greenbelt usually refers to a band drawn fairly tightly around a city or urban region that planners intend to be permanent, or at least very difficult to change. In most cases, greenbelts are created by public or nonprofit purchase of open space lands or of development rights on farmland. Greenbelts are areas of preserved open space, or areas of significantly reduced development, designed as buffers to protect areas of land or water resources from development impacts. The preservation of patches of high-quality habitat, connected by wildlife corridors, can preserve wildlife and ecosystems even in areas with significant adjoining development. Wildlife corridors can serve as “land bridges” between “habitat islands” and as dwelling habitats in their own right (Ewing 1995, 95).

Urban growth boundaries (UGBs) are limits on land development beyond a politically designated area—to curb sprawl, protect open space, or encourage the redevelopment of inner-city neighborhoods (Staley, Edgens, and Mildner 1999). A UGB is a line between urbanization and rural lands, rather than a physical area. Some jurisdictions use the terms *urban limit line* (ULL), *blue line*, or *green line* to mean the actual physical boundary separating urban and rural areas.

UGBs, as they are used in the United States, are (unlike greenbelts) often deliberately designated to accommodate growth for a specified period of time (twenty to thirty years), revisited periodically, and then changed as necessary. Jurisdictions employ a wide range of techniques to implement UGBs, many of which will be described below. But broadly speaking, UGB systems are best known for using regulatory techniques such as zoning to prevent urban development outside the growth boundary.

Washington State, for example, has attempted to deal with the issue of sprawl through the use of urban growth

boundaries established on a countywide basis. In 1990, Washington State promulgated the Growth Management Act, which has a primary goal of minimizing land conversion and environmental impacts by concentrating growth in urban areas. Local jurisdictions, such as city and county governments, were required to work together to prepare comprehensive plans that balanced growth, economics, and land use, while providing affordable housing and other public services. Local jurisdictions were also required to designate specific long-term urban growth boundaries, based on population and economic growth projections through the year 2012 (Robinson, Newell, and Marzluff 2005).

Staley, Edgens, and Mildner (1999) examined the effectiveness and limitations of growth boundaries as growth-management tools in different cases. The growth boundary of Portland, Oregon, is an example of regional land use planning and is used to help reshape the metropolitan area into a higher-density, more compact, transit-oriented city. The growth boundaries of Lancaster County, Pennsylvania, are tied to an aggressive countywide effort to preserve farmland and a unique local culture. Boulder County, Colorado, is attempting to use city-level growth boundaries and highly restrictive county growth controls to slow development while bolstering its reputation as a high-income satellite community of Denver.

Urban containment overlaps to an extent with *growth management*, which, as defined by Nelson et al. (2002), is the deliberate and integrated use of the planning, regulatory, and fiscal authority of state and local governments to influence the pattern of growth and development to meet projected needs. Some containment policies neglect to meet projected needs, and not all growth management policies include urban containment, but a containment program that projects and plans for needed growth would qualify as a growth management program (Pendall, Martin, and Fulton 2004). Robinson, Newell, and Marzluff (2005) examined the effects of growth management efforts on urban fringe areas in Washington State’s Puget Sound region between 1974 and 1998. Their study showed that suburban and exurban landscapes increased dramatically between 1974 and 1998 at the expense of rural and wildland areas. Current growth management efforts prioritize increasing housing density within UGBs while limiting densities outside these boundaries. The study demonstrated that housing density has indeed increased within these boundaries, but at the same time, sprawling low-density housing in rural and wildland areas constituted 72 percent of total land developed within the study area. This has implications for those urban areas, both in the United States and in other countries, considering growth management strategies.

Management programs that attempt to balance growth while fulfilling economic, social, and environmental needs are often termed *smart growth* programs. Such programs may

include a combination of the programs listed above or may focus on a single approach (Porter 1997; Benfield, Terris, and Vorsanger 2001; Gillham 2002). Smart growth underlines some of the form concepts and disregards others. For example, it uses *compactness* on a different scale; that is, it prevents further expansion of the urban fringe rather than supporting extreme compactness or intensification (see Ben-Josef 2000, 122). In addition, it provides for mixed land use to create a mix of housing choices and opportunities, provides a variety of friendly transportation modes, and prevents sprawl through a strategy of compactness (Talen and Ellis 2002, 42; DeGrove 1991). In practice, smart growth discussions in the United States borrow heavily from new urbanist form principles, with an additional emphasis on urban infill development and the cost savings that can result from limiting sprawl. They also emphasize specific techniques such as UGBs, more pedestrian-friendly street design, and mixed-use zoning.

3. Compact City

Prior to the international promotion of the sustainable development agenda, the idea of a radiant city was proposed by Le Corbusier's *La Ville Radieuse* as a solution to the problems of the Victorian city. This was to be done through clearance and the erection of tower blocks, allowing high-population densities within wide-open spaces. Following Le Corbusier's ideas of the radiant city, Dantzing and Saaty (1973) proposed the *compact city*. Their vision was to enhance the quality of life but not at the expense of the "next generation" (p. 10)—an idea that is compatible with today's principles of sustainable development. Generally, the idea of a compact city includes many strategies that aim to create compactness and density that can avoid all the problems of modernist design and cities.

The popularization of sustainable development has contributed to the promotion of the urban compactness idea by enhancing the ecological and environmental justifications behind it. Since the 1990s, research has generally led to the advocacy of cities that are spatially compact, with a mix of uses. Some scholars argue that compact cities offer opportunities to reduce fuel consumption for traveling, since work and leisure facilities are closer together (ECOTEC 1993; Newman and Kenworthy 1989; Hillman 1996). Compact cities are also favored because urban land can be reused, while rural land beyond the urban edge is protected. Ultimately, it is argued that a good quality of life can be sustained, even with high concentrations of people.

The compact form can be implemented on a variety of scales, from urban infill to the creation of entirely new settlements, such as the idea of urban villages in the United Kingdom and new urbanism in the United States (Breheny, Gent, and Lock 1993; Urban Villages Group 1992; Leccese

and McCormick 2000). Generally, compactness proposes density of the built environment and intensification of its activities, efficient land planning, diverse and mixed land uses, and efficient transportation systems.

The European Commission's Green Paper (Commission of European Communities 1990) advocates very strongly the "compact city," assuming that it makes urban areas more environmentally sustainable and improves quality of life. The compact city is being promoted in the United Kingdom and throughout Europe as a component of the strategy formed to tackle the problem of unsustainability. It is proposed that in more compact cities, travel distances are reduced (thus lessening fuel emissions), rural land is saved from development, local facilities are supported, and local areas become more autonomous. Williams, Burton, and Jenks (1996, 83) argue that the actual effects of many of these claimed benefits are far from certain.

Sustainable development is often called upon to provide the basis for the argument for the compact city (Welbank 1996). Peter Newman (2000) found that the compact city emerges as the most fuel-efficient of urban forms. He concluded that urban form does matter, and not just for urban air quality. Some scholars argue that extreme compact city proposals are unrealistic and undesirable. Instead, various forms of "decentralized concentration," based around single cities or groups of towns, may be appropriate (Breheny 1992b).

The main focus has been on the impacts of different urban forms on travel behavior and transport provision, resource efficiency, social equity, accessibility, and economic viability. The outcome of this debate, particularly in Europe, the United States, and Australia, was a strong advocacy of the "compact city" model. Essentially, this is a high-density, mixed-use city, with clear (i.e., nonsprawling) boundaries (Jenks, Burton, and Williams 1996; Williams, Burton, and Jenks 2000). This model was supported for several reasons. First, compact cities are argued to be efficient for more sustainable modes of transport. Second, compact cities are seen as a sustainable use of land. By reducing sprawl, land in the countryside is preserved and land in towns can be recycled for development. Third, in social terms, compactness and mixed uses are associated with diversity, social cohesion, and cultural development. Some also argue that it is an equitable form because it offers good accessibility. Fourth, compact cities are argued to be economically viable because infrastructure, such as roads and street lighting, can be provided cost-effectively per capita. Also, population densities are sufficient to support local services and businesses (Williams, Burton, and Jenks 2000).

4. The Eco-City

The eco-city is an umbrella metaphor that encompasses a wide range of urban-ecological proposals that aim to achieve

Table 1.
Sustainable urban form matrix: Assessing the sustainability of urban form.

<i>Design Concepts (Criteria)</i>	<i>Neotraditional Development</i>	<i>Compact City</i>	<i>Urban Containment</i>	<i>Eco-City</i>
Density	1. Low 2. Moderate 3. High	1. Low 2. Moderate 3. High	1. Low 2. Moderate 3. High	1. Low 2. Moderate 3. High
Diversity	1. Low 2. Moderate 3. High	1. Low 2. Moderate 3. High	1. Low 2. Moderate 3. High	1. Low 2. Moderate 3. High
Mixed land use	1. Low 2. Moderate 3. High	1. Low 2. Moderate 3. High	1. Low 2. Moderate 3. High	1. Low 2. Moderate 3. High
Compactness	1. Low 2. Moderate 3. High	1. Low 2. Moderate 3. High	1. Low 2. Moderate 3. High	1. Low 2. Moderate 3. High
Sustainable transportation	1. Low 2. Moderate 3. High	1. Low 2. Moderate 3. High	1. Low 2. Moderate 3. High	1. Low 2. Moderate 3. High
Passive solar design	1. Low 2. Moderate 3. High	1. Low 2. Moderate 3. High	1. Low 2. Moderate 3. High	1. Low 2. Moderate 3. High
Greening— Ecological design	1. Low 2. Moderate 3. High	1. Low 2. Moderate 3. High	1. Low 2. Moderate 3. High	1. Low 2. Moderate 3. High
Total score	15 points	17 points	12 points	16 points

Note: Scores of the urban forms are highlighted in bold.

urban sustainability. These approaches propose a wide range of environmental, social, and institutional policies that are directed to managing urban spaces to achieve sustainability. This type promotes the ecological agenda and emphasizes environmental management through a set of institutional and policy tools.

The distinctive concepts of the eco-city are greening and passive solar design. In terms of density and other concepts, the eco-city might be conceived as a “formless” city or an eco-amorphous city. There are some approaches that emphasize the passive solar design, such as the Ecovillage, Solar Village (Van der Ryn and Calthorpe 1986), Cohousing (Roelofs 1999, 240-42), and Sustainable Housing (Edwards and Turrent 2000; Boonstra 2000). There are others that emphasize the concepts of greening and passive energy design, among them the Environmental City, Green City, Sustainable City (Girardet 1999; Nijkamp and Perrels 1994; Gibbs, Longhurst, and Braithwaite 1998), Eco-City (Roseland 1997; Engwicht 1992), Ecological City (OECD 1995), Sustainable Urban Living (Girardet 1992), Sustainable Community (Nozick 1992; Paulson 1997), Sustainable Neighborhood (Rudin and Falk 1999), and Living Machines (Todd and Todd 1994).

It is remarkable that the core of many approaches is the *management* of the city, rather than the suggesting of any specific urban form; it is believed that not the physical shape of the city and its built environment that is important; it is how the urban society is organized and managed that counts most. Similarly, Talen and Ellis (2002, 37) argue, “Social, economic, and cultural variables are far more important in determining the good city than any choice of spatial arrangements.”

Therefore, the city is managed to achieve sustainability through different land use, environmental, institutional, social, and economic policies (Robinson and Tinker 1998; United Nations Conference on Environment and Development 1992; United Nations Framework Convention on Climate Change 1992; Council of Europe 1993; European Commission 1994). For example, the well-known Agenda 21 (UNCED 1992) proposes integrated management at the urban level to ensure that environmental, social, and economic factors are considered together in a framework for the sustainable city.

In practice, many local governments, planning consultants, landscape architects, and so on are grappling much more specifically with aspects of ecological, pedestrian-oriented, or otherwise sustainable urban form. I strongly encourage the reader to look at examples from practice.

► Assessment of the Sustainability of Urban Forms

Although this article does not offer hard data to illustrate the most sustainable urban form, it proposes a *sustainable urban form matrix* that aims to help practitioners, policy makers, and others in analyzing and assessing the sustainability of different urban forms according to the design concepts.

The *design concepts* of urban forms are the criteria of the proposed matrix (see Table 1). A scale of 3 points is allocated for each typology (criterion) where 1 represents a *low level of sustainability*, 2 represents a *moderate level of sustainability*, and 3 represents a *high level of sustainability*. For example, a high

density (scale = 3 points) means the urban form is more sustainable, and a low density, such as sprawl, means the urban form is less sustainable (scale = 1 point). Likewise, the more *diverse*, *mixed land-use*, and *compact*, the more the form receives points. In addition, the more the form is based on *sustainable transportation*, *greening*, and *passive solar design*, the more the form contributes to sustainability, and vice versa. Finally, the urban form that scores higher than the others contributes more to sustainability than they do.

This article provides the sustainable urban form matrix, which helps with assessing the sustainability of different urban forms. In addition, it contributes to our selection of those urban forms that are sufficiently sustainable that they meet the requirements of the design concepts (criteria) as mentioned above.

The sustainable urban form matrix in Table 1 provides an assessment of the sustainability of the different urban forms. Significantly, this is a tentative assessment that is based on the literature review of the forms and not on empirical findings or field work. Obviously, one could change the assessment as more evidence comes to light. My ultimate aim is to provide an example based on the proposed matrix. As shown in Table 1, the scores of the urban forms are highlighted in bold in each cell of the matrix (1, 2 or 3), and the final score for each form is the sum of these scores that is presented at the bottom. The results of the assessment, in Table 1, show that the compact city received the highest score followed by the eco-city and then by the neotraditional development. The urban containment received the lowest score.

► Conclusions

The debate over the ideal or desirable urban form dates back to the end of the nineteenth century, to Howard's Garden City. Obviously, the concept of sustainable development revives the previous debate about urban form, develops existing approaches further, and enhances them with environmental rationalization—more precisely, with principles of sustainable development and ecological design.

This study identifies four sustainable urban forms that have many overlaps among them in their ideas and concepts. The different form types are compatible and not mutually exclusive. However, there are some distinctive concepts and key differences for each one of these forms, as follows:

- Compact cities—the distinctive concepts of the compact city are high density and compactness. It proposes mixed land uses like the approaches of new urbanism or neotraditional development.
- The eco-city—emphasizes urban greening, ecological and cultural diversity, and passive solar design. In addition, the approaches of the eco-city emphasize environmental management and other key environmentally sound policies.

- Neotraditional development—emphasizes sustainable transportation, diversity (e.g., of housing types), compactness, mixed land uses, and greening. In addition, neotraditional development has much to do with style and design coding.
- Urban containment—emphasizes policies of compactness.

As this article shows, there are many approaches that aim to achieve sustainable urban forms. Different approaches use different scales of concepts, as well as emphasizing some concepts over others. In practice, many local governments, planning consultants, landscape architects, and so on are grappling much more specifically with aspects of sustainable urban form through a variety of planning and design approaches and policies. The question is, which form is the most sustainable and environmentally sound?

This article outlines a distinctive set of seven concepts by which settlements can be classified in terms of their “environmental burden” and develops a sustainable urban form matrix that can aid and contribute to our evaluation of the sustainability of a given form. Apparently, neither academics nor real-world cities have yet developed convincing models of sustainable form and have not yet gotten specific enough in terms of the components of such form. Regarding that, this article concludes that by using the right scales of the proposed concepts we might be enabled to produce theoretically and practically different sustainable urban forms.

According to the sustainable urban form matrix, this article concludes that different urban forms contribute differently to sustainability. Moreover, different planners and scholars may develop different combinations of design concepts to achieve sustainable development goals. They might come with different forms, where each form emphasizes different concepts. However, all should be forms that environmentally contribute beneficially to the planet for the present and future generations.

The ideal sustainable urban form according to the design concepts of sustainable urban form is that which has a high density and adequate diversity, compact with mixed land-uses, and its design is based on sustainable transportation, greening, and passive solar energy. Ultimately, sustainable urban forms aim to achieve different objectives. The most prominent among them are decreased energy use, reduced waste and pollution, reduced automobile use, preservation of open space and sensitive ecosystems, and livable and community-oriented human environments.

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