

Masdar City: A model of urban environmental sustainability

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In recent years, various proposals have emerged for the construction of “eco-cities,” specially designed communities with an explicit environmental focus that often incorporate technologically sophisticated building design, comprehensive master-planning, renewable energy sources, and efforts to achieve resource self-sufficiency. This trend, however, is subject to intense criticism among some proponents of sustainable urbanism, on grounds ranging from the purported social exclusivity of eco-cities to the claimed incompatibility between a sustainable mode of living and continued economic growth in the contemporary Western model. Masdar City, an eco-city presently being built in the United Arab Emirates, serves as a useful case study in this debate, with such unconventional features as an underground network of tunnels for electric cars and an aim of developing a zero-carbon electricity supply. After examining the Masdar project in particular, and the scholarly context surrounding sustainable urbanism in general, this essay offers a new method for evaluating the environmental and social effects of eco-cities. Using the dual concepts of an “experimental” approach that favors a diverse collection of initiatives for ecologically conscious urban planning and a “human-benefits” perspective that emphasizes inhabitants’ quality of life, the paper concludes that, despite its disadvantages, Masdar City represents an important advance in the field of sustainable urban design.

Located in the desert near Abu Dhabi and under construction since 2007, Masdar City is planned as one of the world’s first completely sustainable communities, combining renewable energy sources and efficient resource usage with traditional Arabian design and spectacular architectural elements¹. As Nicolai Ouroussoff reports in the *New York Times*, the entire city, developed jointly by the architectural firm Foster & Partners and the Abu Dhabi government, is raised on a 23 foot-high concrete base to maximize its exposure to cooling winds and decrease the need for air conditioning¹. Gasoline-powered vehicles will not be allowed on the narrow streets of the city, about one square mile in area, but a fleet of computer-driven electric cars will navigate a complex of tunnels under the concrete base¹. With an expected completion date of 2016, Masdar will require \$22 billion for its construction, furnished by the government and independent investors². Simon Joss of the University of Westminster includes Masdar among a collection of global projects, appropriately named “eco-cities,” that represent the culmination of several decades of theoretical research into sustainable development³. Among advocates of sustainable urbanism, however, eco-cities built on the Masdar model remain controversial, with

numerous scholars criticizing them as socially exclusive and overly dependent on technological improvements in place of broader societal change^{1,4,5}.

Following a review of Masdar City’s master plan, particularly its environmental and social implications, and the current scholarship on sustainable urban design, this paper presents a general framework of analysis for eco-city development, as well as a specific assessment of the benefits and disadvantages of the Masdar project. Substantial progress in lessening the global ecological impact of cities requires widespread public support, and therefore depends on whether sustainable communities will also offer clear benefits for their residents’ quality of life. Although it may perpetuate certain less desirable social effects, Masdar City could serve as the first clear public demonstration that environmental protection can be firmly and tangibly integrated with the development of a more attractive and livable urban community.

From any analytical perspective that might be applied to the city, the most striking feature of Masdar is undoubtedly the city’s ever-present focus on efficiency and optimization, epitomized by a minutely detailed master plan that specifies everything from the type of electricity me-

ters to the facades for the buildings^{1,6}. For a community that aims to accommodate 40,000 residents, 50,000 commuters, and more than 1,500 businesses, this master-planning approach represents an immense and ambitious⁷ undertaking. All buildings at Masdar, designed to maximize the use of natural light, must adhere to strict regulations concerning the use of insulation, low-energy lighting, and energy-efficient appliances⁶. Through these measures, Masdar City is projected to need only a quarter of the energy supply required by a normal city with the same population⁸. Water consumption will be reduced by installing high-efficiency fixtures and appliances and incorporating an advanced network of meters that not only notifies consumers of their usage levels but also determines the location of water leaks throughout the city⁵. In addition, the city’s landscaping, which includes plants selected for their low water requirements, will be irrigated with treated wastewater, allowing Masdar’s total water demand to be less than half that of a regular community⁵.

Despite the fact that few buildings have been completed, Masdar’s developers state that the city is already operating the largest solar photovoltaic plant in the Middle East^{1,5}. Solar panels mounted on the rooftops and projecting over the streets will provide an additional source of energy, along with shade for the pedestrians below⁷. Furthermore, a planned geothermal energy project will pump water into the earth’s crust to produce steam for electricity generation⁹. Some of the city’s waste will be recycled, while some will be incinerated in an electricity-generating process that releases significantly less carbon dioxide than a landfill does^{1,8}. With few sources of fresh water nearby, the city’s water supply will be provided by a desalination facility that uses electricity from a massive hydrogen plant. This hydrogen plant is planned as the world’s largest, and is expected to cost \$2.2 billion¹⁰. Given the sheer size and diversity of its projects, Masdar serves as a showcase for unconventional planning methods and renewable energy technologies that other communities might find difficult to implement without Abu Dhabi’s vast oil wealth. At the same time, the intense concentration on efficiency and renewable resources encapsulates Masdar’s logical appeal: the notion that sustainable urbanism will become a broadly accepted and feasible goal only after someone demonstrates that a city with almost zero carbon emissions is possible on

a large scale.

In its architectural features, Masdar's developers show the same dedication to innovative urban planning, capitalizing on the environmental advantages of traditional Arabian architecture but not hesitating to employ expensive technological solutions. Centuries before the modern era, the people of the region designed their settlements to moderate the desert heat, building on high ground to obtain both defensive benefits and stronger winds and constructing tall wind towers to channel air currents onto the streets¹. Such techniques inspired Foster & Partners to elevate Masdar above the surrounding area, employ wind towers of their own, and incorporate narrow streets oriented at an angle that maximizes shade at the ground level¹. At the center of the developers' vision for the city lies the Masdar Institute, a graduate university affiliated with the Massachusetts Institute of Technology that opened in 2010 and focuses on research and engineering in sustainable technology¹¹. To satisfy Middle Eastern norms for personal privacy, the residential buildings of the campus are enclosed in a wavy facade of concrete latticework, displayed in Figure 1, similar to the traditional screens known as *mashrabiya*¹. While the latticework shields the interior from direct sunlight, the curves provide an angled view that prevents the inhabitants from seeing into the windows of buildings across the street¹. In accordance with local custom, the campus is also segregated by gender, placing the living quarters for single men on one side and those for women and families on the other¹. These aspects of the city's design contrast sharply with the distinctively modern style of the main buildings in the Institute, including the Knowledge Center, which houses study spaces under an iconic spherical roof covered with solar panels and zinc cladding¹², as seen in Figure 2.

Masdar's master plan expresses a sense of order and authority, founded in its developers' confidence that they can remake the whole structure of urban life through technological improvements, careful design, and active civic management. This observation is well illustrated by the "Personal Rapid Transit" system of automated electric cars, envisioned as a more efficient and attractive version of a public transportation network⁶. By eliminating not only gasoline usage but also the entire concept of the private automobile, the city's architects are transforming social standards and creating a new pedestrian community,



Fig. 1 The concrete facade of a building at the Masdar Institute.

easing the transition by offering almost exactly the same degree of comfort and convenience. From its developers' standpoint, Masdar City strengthens its emotional resonance with the promise of environmental protection and social revitalization that rise organically from the established local culture, essentially fusing modernity and tradition. In its larger structure, depicted in the artist's impression shown in Figure 3, the city exudes an aura of geometrical design, with the buildings arranged in neat squares, areas of solar panels and processing facilities placed around the outskirts, and parks occupying the remaining spaces. Of course, the city's architects could have the freedom to realize this ideal only in a sparsely populated desert region with extensive government funding.

In parallel with its promotion of sustainability, Masdar also furnishes a classic example of a development motivated by the financial potential of new technologies used to combat emerging social concerns. Over the next twenty years, the emirate of Abu Dhabi intends to use the Masdar project to encourage private entrepreneurship, facilitate scientific research in renewable energy, and generate economic growth in areas other than the oil industry⁶. As a special economic zone within Abu Dhabi,



Fig. 2 A view of the Knowledge Center at the Masdar Institute.

the city offers a zero-percent tax rate on income and imports, and permits the establishment of businesses that are wholly foreign-owned¹³. The developers argue that sustainable building practices will be adopted on a sufficiently broad scale to combat climate change only if environmentally conscious urban planning proves economically appealing⁶. Consequently, the meticulous master-planning approach that Masdar exemplifies might impose a level of social change that would be unacceptable for many people, and at the same time conform excessively to the conventional economic norms underlying Abu Dhabi's carbon-intensive culture. Currently, the United Arab Emirates possesses the world's highest per capita ecological footprint, a measure of the biological capacity required to fulfill resource demands and absorb waste emissions¹⁴.

Indeed, the fundamental question of the extent to which sustainability requires profound societal and economic change applies not only to Masdar, but also to every other proposal in the literature on sustainable development. Many different models of sustainable urbanism have been devised, as Yosef Rafeq Jabareen, an urban studies lecturer at the Massachusetts Institute of Technology, explains in his article, "Sustainable Urban Forms: Their Typologies, Models, and Concepts."¹⁵ "Neotraditional development," also known as the "new urbanism," seeks a more vibrant sense of community and more architecturally appealing development patterns, concentrating on mixed land use, walkable public spaces, diverse housing types, and somewhat higher population densities¹⁵. In another approach, "urban containment" efforts intend to lessen suburban sprawl by employing greenbelts, mass transit, and various regulatory policies¹⁵. In comparison with urban containment, as Jabareen notes, other initiatives promoting the idea of the "compact city" support a far higher level of building density and mixed land use, dramatically minimizing the demand for automobile travel¹⁵. Lastly, proposals for the "eco-city" emphasize urban greening and "passive solar design," which involves the efficient use of sunlight and absorbed heat in buildings, with a notable focus on the active management of social and economic life in the community¹⁵.

In his survey of eco-cities, Joss notes that about three-fourths of current eco-city projects rely primarily on technological innovation rather than a more

holistic platform, including social and cultural aspects such as social justice and local democracy⁴. On this basis, Mike Hodson, a research fellow at the Centre for Sustainable Urban and Regional Futures (SURF) at the University of Salford, and Simon Marvin, a professor at Salford and the co-director of SURF, criticize recent eco-city proposals as socially regressive¹⁶. As their article “Urbanism in the Anthropocene: Ecological Urbanism or Premium Ecological Enclaves?” argues, cities must now guarantee their “ecological security” by safeguarding resources such as water, energy, and food supplies amid the uncertainties of climate change and a globalized economy⁴. Hodson and Marvin describe the emerging pattern of “integrated eco-urbanism,” in which new developments “build ecological security by internally producing their own food, energy and other critical resources, reusing wastes as resources and reducing reliance on external infrastructures.”⁴ This approach, typified by Masdar City, emphasizes technological solutions, especially renewable energy sources, to overcome resource constraints in independent, self-sufficient enclaves⁴. From their perspective, eco-cities are offering ecological security as a “mobile financial product” that only the wealthy can afford, while excluding other social groups and failing to introduce any truly substantial behavioral or economic changes⁴.

While Hodson and Marvin outline a socially oriented analysis, Susanna Myllylä of the University of Tampere and Kristiina Kuvaja of the University of Jyväskylä offer a critique of the eco-city movement from the perspective of the global “South,” their term for developing countries⁵. In “Societal Premises for Sustainable Development in Large Southern Cities,” they assert that the current concepts of an “eco-city” or an “ecological city” embody essentially “Northern” values and methods, prioritizing technocratic, managerial, and commercial strategies to combat environmental problems⁵. Eco-cities presuppose certain societal and governmental structures, particularly a democratic political system and an established civil society, when the formation of these structures itself presents a central challenge for communities in the South⁵. Indeed, as Myllylä and Kuvaja contend, efforts to implement sustainable urbanism in the South through Northern technological methods usually result in exclusive “ecological islets” surrounded by poor and environmentally de-

graded neighborhoods⁵. Instead, Myllylä and Kuvaja recommend a concentration on effective governance and civil society, as well as social justice and equity, noting that the pursuit of merely environmental sustainability as a goal in itself could worsen unjust social conditions⁵.

In some ways, the diversity of perspectives on urban sustainability seems to arise from fundamental disagreements about sustainable development as a concept, particularly about whether planners should attempt to ameliorate specific environmental problems, or strive for a more comprehensive transformation of human society. According to Mark Roseland of Simon Fraser University, the very notion of sustainable development assumes that environmental protection can be reconciled with economic growth in a capitalist system¹⁷. While poverty is commonly viewed as a cause of environmental degradation, Roseland argues that both poverty and damage to the environment are actually produced by wealth¹⁷. To achieve the objectives of sustainability, he maintains that “we must . . . shift our economic development emphasis from the traditional concern with increasing growth to reducing social dependence on economic growth.”¹⁷ Likewise, in his article “Synergy City: Planning for a High Density, Super-Symbiotic Society,” John Wood presents the case that the economic success of the developed world is based on the availability of inexpensive fossil fuels¹⁸. A researcher from the department of design at the University of London, Wood asserts that an ecologically conscious form of society is directly opposed to one that promotes consumerism, convenience, and profit, calling instead for people to adopt more “synergistic,” collaborative lifestyles¹⁸.

Many scholars believe, however, that modern society and economic prosperity are indeed compatible with vigorous efforts to protect and preserve the environment. For instance, in *The Human Sustainable City*, a compilation of scholarly articles on sustainability, Stefano Zamagni of the University of Bologna discusses an interesting statistical finding that could undermine Roseland’s premise that environmental damage results from wealth. Although environmental decay increases with the growth in average income when the latter remains low, it decreases with income growth once the average annual income has exceeded a threshold of approximately \$8,000 per capita¹⁹. Another

paper in *The Human Sustainable City*, by Peter Hall of University College London, contends that ecological degradation harms economic development, and that the protection of the environment can promote economic growth²⁰. Finally, Michael Breheny, a professor of Applied Geography at the University of Reading, advises caution in instituting drastic social changes for environmental aims. He produces evidence from surveys in Britain that the extensive social changes entailed by urban compaction, a frequently promoted method of reducing cities’ environmental impact, would be strongly resisted by most residents²¹. As Breheny argues in another article, proposals to shift communities to the model of the compact city, with higher densities and greater provision of public transportation, would demand draconian regulatory regimes but yield, at maximum, about a 30% decrease in automobile energy consumption²².

Practical examples of the implications of these different theoretical approaches to sustainable development can be found by comparing Masdar City to some of the various envisioned, or actually constructed, eco-cities around the world. As the *New York Times* reported in 2007, for example, the Chinese government, in partnership with the British engineering firm Arup, was planning to establish the Dongtan eco-city on an island in the Yangtze River²³. In the city, designed to accommodate 500,000 inhabitants, electricity would be supplied by solar panels, wind turbines, and the burning of discarded rice husks, while gasoline-powered cars would be prohibited²³. Farms and parks would occupy most of the island’s land area, and almost all waste generated by the city would be recycled through an automatic sorting system integrated into the streets²³. Nevertheless, by 2010, when the first phase was supposed to be finished, the completion of Dongtan was indefinitely postponed and most construction work was suspended²⁴. The reasons for the apparent abandonment of the project included uncertainty concerning whether it would be funded by Arup or the government, as well as the failure of the developers to engage the local community in the planning process²⁵.

Curitiba, a city in Brazil that is also classified as an eco-city, provides an illustration of a more successful attempt at environmentally beneficial urban planning, with an especially notable feature being its innovative bus system^{3,26}. As Arthur Lubow

describes in the *New York Times Magazine*, specially designed buses, operating on dedicated avenues and arriving at each stop once every 30 seconds during peak hours, transport 2.3 million people per day, more than two-thirds of the metropolitan region's total population²⁶. In the 1970s, Curitiba converted its downtown shopping district into a pedestrian zone, blocked the entry of polluting industries, and increased the land area devoted to parks and open spaces dramatically, from 5 square feet for each person to 540 square feet²⁶. Recently, nevertheless, the city's per capita car ownership has risen to the highest in Brazil, and its recycling rates have been decreasing, with some residents attributing these trends to low public participation in planning decisions and limited community willingness to adopt sustainable behaviors²⁶.

Not coincidentally, Curitiba's environmentally progressive master plan was formulated when a military dictatorship ruled the country²⁶, in a remarkable parallel with the authoritarian Chinese government's support for Dongtan, and Masdar's dependence on the hereditary emirate of Abu Dhabi. Comprehensively master-planned eco-city projects necessitate such large expenditures and strict regulations that only non-democratic governments might be capable of developing eco-cities on a large scale. For instance, as Danyel Reiche of the American University of Beirut notes in "Renewable Energy Policies in the Gulf Countries: A Case Study of the Carbon-Neutral 'Masdar City' in Abu Dhabi," political power in the United Arab Emirates remains mostly with the seven emirs⁷. At the federal level, foreign affairs and defense are coordinated by the emirs, and political parties are banned; oil and natural gas reserves are controlled by the individual emirates, accounting for the striking wealth of Abu Dhabi, where almost all the country's energy resources are located⁷. Governmental decisions are strongly influenced by personal access to the ruling family: Reiche reports that the idea for building Masdar was developed by Lebanese engineers in contact with the crown prince of Abu Dhabi, who conveyed it to the emir⁷. In another article, he writes that the Gulf monarchies, such as the United Arab Emirates, are impeded in efforts to advance sustainability by their reliance on oil revenues. Using income from oil exports, these regimes gain popular acquiescence to the lack of political rights by imposing low taxes, offering free medical

care, and subsidizing energy supplies¹⁴.

As the examples of Curitiba and Dongtan show, however, even with strong initial support from the government, attempts at ecologically conscious development can falter when they are not grounded in widespread public acceptance of sustainability measures and strong community involvement in the planning process. For example, Lurton Blassingame of the University of Washington at Oshkosh observes in a review of urban sustainability endeavors that residents must be willing to alter their ways of life, not only in terms of environmental impacts but also with respect to socioeconomic changes²⁷. In *Psychology of Sustainable Development*, a collection of papers on environmental psychology, Elisabeth Kals and Jürgen Maes of the University of Trier in Germany identify several factors contributing to engagement in sustainable behaviors. Some of the most important elements include "ecological awareness" about environmental problems, the belief that one's actions exert a substantial influence on the extent of ecological damage, and "emotional affinity" toward nature²⁸. Hence, the question of how people can be induced to accept sustainable practices becomes partially a question of how their awareness of the natural world and their emotional connection to it can be reinforced.

Nonetheless, some scholars in sustainability studies are unfortunately inclined to discuss environmental issues in ways that seem unlikely to promote greater public understanding of ecological concerns and support for sustainability initiatives. Wood, for instance, advocates the use of urban design in a "frankly manipulative" manner that involves "a process of 'seeding' consensual change"¹⁸. Later he writes, "Not surprisingly, consumer-centred, representative democracy has conspicuously failed to wean us from a way of life that threatens us with extinction."¹⁸ Besides providing no scientific justification for his claim that the very survival of the human species is imperiled, Wood's statement may hold limited motivational force; Kals and Maes explain that "ecological fear" of detrimental effects from the environment on one's well-being has only a minor impact on behavior²⁸. Another author, Peter H. Cock of Monash University, opens his paper in *Psychology of Sustainable Development* with a similarly startling sentence: "Hidden behind the blindness of our suicidal cultures is an insidious biophysical

poisoning."²⁹ Cock also espouses a "Sacred Ecology" emphasizing "the spiritual journey of self-transcendence and inner reflection activated through encounters with the 'otherness' of other species and their habitats."²⁹ Calls for a transformation of religious morality and vituperative remarks about the societies in which people live will probably be unable to persuade large majorities of citizens in the Western world to modify their ways of life in favor of sustainability.

On the basis of both the theoretical and practical aspects of urban sustainability, one can develop a new framework for assessing efforts to create more sustainable communities. This proposal recognizes that climate change and ecological degradation occur on a global scale, and that efforts to protect and restore the environment require widespread public support across nations and social groups. Any solution must emphasize community participation in urban planning and, most importantly, combine environmental benefits with demonstrable improvements for residents' quality of life. All these criteria are satisfied by an "experimental" method that embraces many divergent, and even philosophically opposed, approaches to the task of reducing the worldwide environmental impact of cities. Indeed, as Solon L. Barraclough of the United Nations Research Institute for Social Development aptly states, "A unified approach to promoting sustainable development in diverse contexts is a utopian illusion."³⁰ With radical differences in economic, social, and political conditions between countries and even between neighborhoods in the same city, the "experimental" method acknowledges that each community must implement techniques and policies particularly designed for its own local circumstances.

Ultimately, the concerted and inventive application of these ideas in urban communities throughout the world should result in the development of what might be called "human-benefits" cities that would secure broad advantages for both the health of the natural environment and the standard of living for all inhabitants. These cities would embody the central principle that ecologically sustainable communities should simply be authentic and attractive cities in general, with lower pollution, improved health, greater social solidarity, and a strong appreciation for the beauty and complexity of nature. In contrast to the many sustainability proposals, such



Fig. 3 An artist's impression of the master plan for Masdar City.

as those of Wood or Myllylä and Kuvaja, that also seek improvements in aspects of urban life besides the environment, the “human-benefits” perspective does not fix any particular objectives other than ecological protection. Some cities might pursue social justice, some might strive for economic revitalization, and others might concentrate on cultural and educational opportunities: the “experimental” method allows each city to follow the priorities of its own residents. With this proposal, developers and municipal officials would eschew externally designed master plans in favor of broadly supported initiatives arising organically from recognized local concerns.

“Human-benefits” cities would focus on incentives for adopting sustainable behaviors rather than penalties for violating environmental regulations, seeking to maintain the interest and engagement of businesses and residents. This recommendation is inspired by the findings of Karen Umemoto and Krisnawati Suryanata, professors at the University of Hawaii at Manoa. They discuss the use of “informal social contracts” to develop trust and reciprocity between a mariculture company and local inhabitants and to resolve conflicts over environmental impacts without expensive litigation³¹. In the same manner, instead of an excessive reliance on legal constraints, cities can dissolve contention by implementing a problem-solving methodology that attempts to achieve advantages for all parties involved. Furthermore, the “human-benefits” approach would encourage the construction of new communities only in environments naturally suitable for human life, not in inhospitable deserts or

ecologically fragile rainforests. Using locally sourced building materials and supporting research into sustainable technologies would yield not only more sustainable patterns of construction, but also benefits for the local economy. Most importantly, this proposal would offer more opportunities for innovation, greater public participation in civic decisions, and even more personal freedom. As Hall argues, “If there is an argument for higher densities and particular urban forms, it is far more that these give people more choice, not less: freedom to take good public transport rather than be car-dependent, freedom for their children to walk or bike to school rather than being ferried by car.”²⁰ This approach solves the problem of ecological awareness and motivation, not by erecting an entirely new system of environmentally conscious values and ethics, but by drawing on the interest that humans have perennially placed in their own health, their communities, and improved living conditions for their families.

Applying this analysis to Masdar City specifically, one can identify clear disadvantages for the project, especially since the planning process has been controlled by the government for its own purposes, rather than responding to the concerns and desires of the local community. Indeed, the city is isolated from any other community by the surrounding deserts, and the high concrete base would prevent Masdar from being naturally integrated with any nearby neighborhoods that might exist in the future, raising the issue of social exclusion. As Hodson and Marvin suggest, moreover, while eco-cities are generally new devel-

opments, ecological security should be extended to the less privileged by focusing on retrofitting and behavioral change in existing cities⁴. Nevertheless, the “experimental” method does not demand that myriad ecological and social objectives all be advanced by a single initiative: as Blassingame notes in his article, sustainable development is a process, not a final product²⁷. Even if it is lacking in certain respects, Masdar City represents profound progress in the central task of demonstrating the feasibility of a “human-benefits” city that purposefully connects environmental protection, economic opportunity, and an improved quality of life in a unified and potent vision. Specially designed, self-contained eco-cities can be effectively used to stimulate sustainable development in existing neighborhoods, but their architects should expect them to be incorporated into the larger community as environmentally conscious design is more broadly adopted in the future.

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References

1. Ouroussoff N. “In Arabian Desert, a Sustainable City Rises.” *New York Times*. 25 Sept. 2010.
2. Bullis K. “A Zero-Emissions City in the Desert.” *Technology Review* 2009; 56-63.
3. Joss S. “Eco-Cities—A Global Survey 2009.” *WIT Transactions on Ecology and the Environment* 2010; 129: 239-50.
4. Hodson M. and Marvin S. “Urbanism in the Anthropocene: Ecological Urbanism or Premium Ecological Enclaves?” *City* 2010; 14: 298-313.
5. Myllylä S and Kuvaja K. “Societal Premises for Sustainable Development in Large Southern Cities.” *Global Environmental Change Part A* 2005; 15: 224-37.
6. “What is Masdar City?” 2011. Masdar City. <<http://www.masdarcity.ae/en/27/what-is-masdar-city>>.
7. Reiche D. “Renewable Energy Policies in the Gulf Countries: A Case Study of the Carbon-Neutral ‘Masdar City’ in Abu Dhabi.” *Energy Policy* 2010; 38: 378-82.
8. Fortson D. “Green City Rises from Desert—Abu Dhabi Is Building a \$22 Billion Zero-Carbon Showcase City for 50,000 Residents. Danny Fortson Went to See Its Beginnings.” *Sunday Times* [London] 1 Feb. 2009, 2nd ed.
9. Gavin J. “Taking the Lead on Clean Energy.” *MEED: Middle East Economic Digest* 2009; 40-41.
10. James E. “Hidden Costs of Alternative Energy.” *MEED: Middle East Economic Digest* 2008; 30-31.
11. “Official Opening of the Masdar Institute

- Campus, First Solar Powered Building at Masdar City." 23 Nov. 2010. Foster & Partners. <<http://www.fosterpluspartners.com/News/428/Default.aspx>>.
12. "Knowledge Center." 2010. Masdar Inst. of Science and Technology. <<http://www.masdar.ac.ae/campus/KnowledgeCenter.php>>.
13. "Special Economic Zone." 2011. Masdar City. <<http://www.masdarcity.ae/en/38/special-economic-zone>>.
14. Reiche D. "Energy Policies of Gulf Cooperation Council (GCC) Countries—Possibilities and Limitations of Ecological Modernization in Rentier States." *Energy Policy* 2010; 38: 2395-403.
15. Jabareen YR. "Sustainable Urban Forms: Their Typologies, Models, and Concepts." *Journal of Planning Education and Research* 2006; 26: 38-52.
16. *SURF: The Centre for Sustainable Urban and Regional Futures*. 2011. U of Salford.
17. Roseland M. "Sustainable Community Development: Integrating Environmental, Economic, and Social Objectives." *Progress in Planning* 2000; 54: 73-132.
18. Wood J. "Synergy City: Planning for a High Density, Super-Symbiotic Society." *Landscape & Urban Planning* 2007; 83: 77-83.
19. Zamagni S. "Sustainable Development, the Struggle against Poverty and New Structures of Governance in the Era of Globalization." In: Luigi Fusco Girard et al eds. *The Human Sustainable City*. Aldershot: Ashgate, 2003: 121-39.
20. Hall P. "The Sustainable City in an Age of Globalization." In: Luigi Fusco Girard, et al eds. *The Human Sustainable City*. Aldershot: Ashgate, 2003. 55-69.
21. Breheny M. "Urban Compaction: Feasible and Acceptable?" *Cities* 1997; 14: 209-17.
22. Breheny M. "The Compact City and Trans-

- port Energy Consumption." *Transactions of the Institute of British Geographers* 1995; 20: 81-101.
23. Brass K. "Breaking Ground on Eco-Cities near Shanghai." *New York Times*. 4 July 2007.
24. Sanford L. "A Tale of Two Eco-Cities." *Modern Power Systems* 2010; 20-22.
25. Brenhouse H. "Plans Shriveled for Chinese Eco-City." *International Herald Tribune*. 24 June 2010.
26. Lubow A. "The Road to Curitiba." *New York Times Magazine* 2007.
27. Blassingame, Lurton. "Sustainable Cities: Oxymoron, Utopia, or Inevitability?" *Social Science Journal* 1998; 35: 1-13.
28. Kals E and Maes J. "Sustainable Development and Emotions." In: Schmuck P, Schultz W eds. *Psychology of Sustainable Development*. Boston: Kluwer, 2002. 97-122.
29. Cock PH. "Partnerships for Sustainability: Psychology for Ecology." In: Schmuck P, Schultz W eds. *Psychology of Sustainable Development*. Boston: Kluwer, 2002: 175-95.
30. Barraclough SL. *Toward Integrated and Sustainable Development?* UNRISD Overarching Concerns 1. Geneva: United Nations Research Inst. for Social Development, 2001.
31. Umemoto K and Suryanata K. "Technology, Culture, and Environmental Uncertainty: Considering Social Contracts in Adaptive Management." *Journal of Planning Education and Research* 2006; 25: 264-74.

Figure References

1. "What Is Masdar City?" 8 June 2011 <<http://www.masdarcity.ae/en/27/what-is-masdar-city>>.
2. "Knowledge Center," Masdar Institute of Science and Technology, 8 June 2011 <<http://www.masdar.ac.ae/campus/KnowledgeCenter.php>>.
3. "What's Next?" 8 June 2011 <<http://www.masdarcity.ae/en/36/whats-next>>.



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