

CLIMATE, CITIES AND SUSTAINABILITY IN THE ARABIAN REGION: COMPACTNESS AS A NEW PARADIGM IN URBAN DESIGN AND PLANNING

Mustapha Ben-Hamouche

Abstract

Over centuries, the climate in Arabia has become a major factor that shaped daylife of the local societies and thus, the form of their cities. Old cities were characterized by their compactness which stemmed from the need for protection from the harsh environment. Urban fabric has been dominated by the building masses, the limited number of enclosed public and outdoor spaces, and the inward-looking architecture. Besides its environmental utility, compactness also provided a physical support to the local community and reflected its strong social structure and complex network of kinships. Nowadays, Gulf cities that are mostly shaped by the modern movement and American life style (comma removed) are in complete negation with their past. An unprecedented sprawl effect is taking place all over the Gulf countries due to the heavy reliance on private transportation, high building technology, powerful air-conditioning systems and private housing. Reconsidering compactness in the present urban planning and design practices, would not only insure a cultural continuity with the rooted urban history of the region, but also meets the recommendations of the recent findings in research on sustainable urban development. Modeling compactness from the study of the old cities into urban indicators and design guidelines would provide an alternative design and planning process to architects, planners and decision-makers. Far from being exhaustive, the study consists

of analyzing some old cities that are located in the hot regions, according to the available documents, and extracting urban indicators that help measuring and applying compactness in planning and design.

Keywords:

Hot-climate; compactness; urban planning; design guidelines; urban indicators; sustainability.

Introduction

Climate has always been a major factor in the shaping of cities. In hot regions such as the Arabian-Persian Gulf, daily life including dressing, food and social conduct as well as urban forms were to a large extent dictated by the sun's path and heat. Old cities were compact in order to respond to the need for protection from the sun's heat and harsh environment.

By the advent of modernity, a radical change in the urban forms as well as social conduct occurred. Cities were planned to adopt the political and social aspirations for progress and to reflect the symbols of modernity such as private transportation, wide roads, individual

The initial material of this paper was presented in the Sharjah Urban Planning Symposium, Sharjah, United Arab Emirates, April 4-6, 2004.

housing and zoning for land-use, free standing glazed towers and mass parking in the heart of the cities. A dispersed form of building entities thus gradually replaced the old compact model within a life-span of three to five decades.

Recently however, studies showed that such a shift is increasingly having negative impacts on most aspects of human life. The new model is not only disadvantageous to the environment but is also causing rupture with rooted traditions, degeneration of community sense, and economic deficiency.

The aim of this paper is to highlight the concept of compactness over history, to prove its validity for today's planning practices, and to develop the convenient instruments that help planners and professionals measure it, and apply it in urban development and design.

Compactness as a New Paradigm

World urbanization is increasingly becoming the source of environmental degradation and dilapidation of natural resources. Cities witness a continuous outward expansion that is believed to be unsustainable. Compactness is thus increasingly becoming a key word in the recent urban studies that relate the concept of sustainability to the built forms. The compact city is becoming the subject of numerous studies in the search for empirical evidences advancing the claimed effects of compact built form on sustainability. A list of advantages were enumerated to prove, at least at the theoretical level, the outweighing of the compact model over the present dispersed one (Chain et al., 2008: 29-30, Thinh 2002 p476, Whiteford V. et al. 2001).

Among its claimed advantages are the conservation of land, the reduction of reliance on car, thus the reduction of fuel emissions, the support of public transport and walking and cycling, the increase of access to services and facilities, the efficiency in the distribution and provision of utilities and infrastructure (Burton 2002,219, Chain et al., 2008: 29-30). However, such studies, despite their global scale, are mostly based on the experiences of the developed countries, (USA, Europe, Japan and Australia). Cities in less-developed countries, despite their present tremendous growth rates and their long history in urbanization that evidently precede the West, are thus virgin cases for such studies (Chain et al. 2008, Catalan 2008).

In the case of the Middle East and North African (MENA) region, the study of compactness would have other dimensions such as the continuity with the long urban history that lasted thousands of years, the social structure that reflects the tribal system and strong kinships, the responsiveness to the hot climate in both energy-saving terms, and thermal comfort at the city level.

On enshrining compactness in today's urban planning and land-use however, its meaning is the first debate, with the second being the techniques for measuring it (Thans 2002, Burton E 2002). Regarding its meaning, it was broadly accepted that it depends on the scale of approach that varies from the regional level to the block and building level (CNU 2000, Crane R. and Crepeau R. 1998, Stanley B. 2005, Eben-Saleh 2005). At the city and neighbourhood level, which is the scope of this study, compactness mostly relates to high density, mixed and intensified land-use, and urban form. Instruments for measuring compactness

are, however, still under study (Chain et al. 2008, Catalan 2008, Eben-Saleh 2005). They are believed to depend on the local circumstances which cannot be standardised. In practice, a major problem of such instruments is that their complexity too often based on mathematical models, a fact that they make them out of reach of professionals, architects and planners, and decision-makers.

Measuring Urban Compactness

The present study departs from the hypothesis that considers compactness as a major factor of sustainability. On aspiring for practical results, the recommendations of (Istanbul +5) declares that success (and failure) in social and environmental development towards sustainability should be measured through urban indicators (Etzion Y. 1994). However, despite the extensive literature on sustainability and urban indicators, many aspects of urban planning and design have not yet been covered. Examples of such aspects are climatic responsiveness and social cohesion. Regarding the few existing ones dealing with urban form and planning in general, there seems to be no effort to make them at the hands of planners and architects, as most of them are dominated by their technical aspects (Assis (de) E.S. et al. 1999, Golany G. S. 1996, Kilical A.A. 1990, Eliasson I. 2000, Burton 2002).

The aim of the present study is thus to contribute to the universal discourse on sustainability through the definition of some practical indicators that help achieve compactness in the light of the Muslim-Arab city gaining experience. Practicality requires that these indicators should be few, simple and clear enough to be used

by professionals as an alternative to current practices.

It is believed in this study that the inherited cities could help in the calculation of the required indicators. They are deeply rooted in the history of human civilization and thus reflect the maturity of the human mind in the making of cities. The old Arab-Muslim cities, mostly located in the hot regions are believed to reflect this condition and be the extreme examples and bottom line of compactness. They represent valid, reliable and plausible sources of reference for measuring compactness. It is, however, obvious that their high degree of compactness could not be fully adopted in the planning and design of today's settlements due to the change in the standard of living, the technological advancement that introduced private transportation, and the air-conditioning system, as well as the increasing individuality that dominates the community life. However, their presence will form a starting point and a landmark to the academia as well as the professionals to elaborate more suited indicators according to the local conditions of each community.

Indicators for Compactness

In searching for an approach for assessing urban compactness, studies are hindered by the absence of recognized indicators for both urban compactness and urban sustainability (Jenks & Burgess, 2000). Large sets of indicators are however available (Chen et al. 2008: 33). On analyzing compactness in Chinese cities, Chen et al. limited their study to the population density dimension. Burton (2002) developed a set of density, mix-use, and intensification indicators to measure compactness of 25

English towns. Softwares were developed to simulate and measure compactness. Thans et. Al (2002) used GIS in representing German cities as a grid of sealed cells reflecting the building density, and calculating the distance between the black clusters. A set of urban models based on cellular automata (CA) techniques were developed for better understanding of urban evolution. Li Xia et al. (2008:185) tested the (CA) techniques to simulate, predict, and optimize urban development in a Chinese region to promote compact cities by using local rules. In negation to compactness, approaches were adopted to assess the urban sprawl in present cities through the study of land-cover change in

a given period of time (Catalan et al. 2008: 177).

In the Present study, the analysis is limited to the urban form of six selected traditional cities (figure 1). In the absence of other vital data such as population density, land-use, car-ownership and transportation systems, that could if they exist, surely refine the results, the study is limited to three indicators that are believed to help measuring urban compactness.

Indicator I concerns land-use at the city level. It shows the percentage of land covered by buildings within the urban perimeter. Built-up area comprises all types of constructions

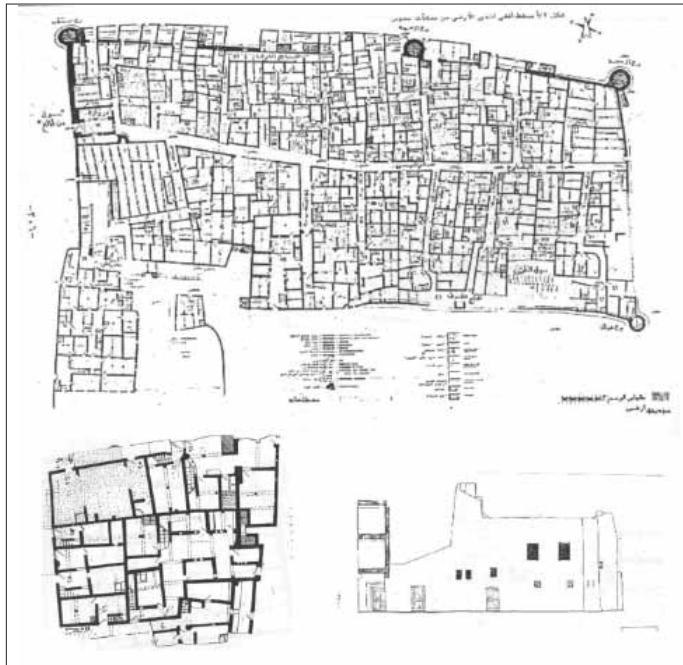


Figure 1(a,b,c): The Old City of Sudus, Saudi Arabia as an Example of the Case Study Documents used for the Calculation of Urban Climatic Indicators shown in table 1. (Source: Uthman, 1996).

including public facilities as well as housing. The remaining percentage that is formed of streets, squares and derelict land within the city wall is therefore void.

Indicator II represents the intensity of building in private parcels. Courtyards and private open spaces are generally surrounded by the building mass. A typical form consists of a house that has a square form within which a courtyard occupies the centre.

Indicator III concerns the relationships between the mass and the void in the external envelope of buildings which is simply represented by the percentage of openings, doors and windows, in the mass of the elevations and walls. Due to

the inward typology, a building might have an internal envelope that opens onto courtyards which gives on the public space.

A comparative table of ratios is then established from the calculation of the indicators for the selected cities (table 1) . Cities are classified according to their climate in two categories: the arid and the hot-humid climates. Due to the lack of data on density of population, types and intensities of land-use in each of these cities, the study is limited to their typology and morphologic aspects.

The accuracy of the present results was also subject to the available material on the selected cities. While some of them, like Sudus and

The City	Cities in Hot Humid Regions			Cities in Arid Regions		
	Manama (Bahrain)	Muharraq (Bahrain)	Hofuf (Saudi)	Sudus (Saudi)	Ghardala (Algeria)	Fez (Morocco)
Date of foundation (AD)	Around 1900	Around 1900	930	Around 1700	11 th Century	789
Location (lat. & long.)	51 East 26 North	51 East 26 North	49 East 25 North	46 East 25 North	04 East 03 North	05 West 34 North
% of Streets & open spaces	27.19	30.76	21.7	17.76	13.22	10.28
% of courtyards	10.74	8.00	12.44	13.97	3.65	12.60
Total of openness	37.93	38.76	34.14	31.73	16.87	22.88
% of Built-up areas	62.06	61.24	65.86	68.27	83.13	77.12
Ind1= Public Void/Mass	0.37	0.44	0.28	0.21	0.15	0.11
Ind2=Private Void/Mass	0.17	0.13	0.18	0.20	0.04	0.16
% of openings to outside	35.8	39.05	14.00	8.74	4.9	?
% of Openings to inside	41.40	49.50	32.50	5	?	21.04
Ind3=Openings/facades	0.56	0.63	0.16	0.09	0.05	?

Table 1: Comparison of Different Cities Located in Arab Hot Regions
Documents on these cities is drawn from the following sources: Wali T. 1986, Uthman, M.A.S. 1996, Olgay V. 1973, Al-Hathloul S.A. et al. 1975, Al-Naim M. 1998, Majed E.I. 1987, Bianca S. 2001, Donnadieu C et al. 1977, Al-Khenaizi O. 1994, Ministry of Housing, Municipalities & Environment, Bahrain 1999. Maps and drawings on buildings and elevations were scanned and then digitized in order to calculate the different ratios.

Manama have been thoroughly covered at the morphological level, others such as Ghardaia and Hofuf depended on a few surveyed parts of the cities.

Indicator I: The Public Void/Mass Ratio

The most common characteristic of the desert cities that could be deduced from the table is the domination of the mass over the voids at the city level (figures 2 a & b). Voids that include streets and open areas have ratios that range between 0.13 and 0.44. Aerial views show these cities in a form of a continuous body that is perforated with squares for courtyards and lines of winding streets. The most compact city in the selected set is Fez that has openness only 0.11.

Public void/Mass indicator in the humid region is however significantly higher as it ranges between 0.28 and 0.44. This is generally due to the need for continuous evacuation of humidity. Large, long, and straight street lines play the role

of canyons that accelerate wind movement (Chan A. T. et al. 2001, Golany G. S. 1996, p462). Other open spaces such as public courts and plazas are generally minimized in both cities as they are source of heat gain.

Indicator II: The Private Void/Mass Ratio

This indicator for both categories of cities ranges between 0.13 and 0.20. There seems to be no significant difference between the two climatic classes at the private level. It is however exceptionally low in the case of Ghardaia (0.04) which could be considered as the minimum openness ratio that a human settlement could reach. Most houses in this city are of two levels. In order to reduce the incoming sun-rays to the house, the void of the courtyard in the roof is much smaller than that of the first level. The very small amount of light coming from that void suffices all the rooms at the ground level. A person entering the house for the first time will feel that most spaces are dark. However, after



Figure 2a: Muharraq City in Bahrain, 1966 (Source: Directorate of Survey, Bahrain).



Figure 2b: The Urban Fabric of Muharraq City (Source: Directorate of Survey, Bahrain).

a few minutes he/she gets used to the space and feels that the darkness is coupled with the freshness.

It could be deduced then that the percentage of openness in buildings in both types of cities is the same. Courtyards are generally the major elements that provide buildings with air and light. Sometimes, they are treated with vegetation and water elements to create microclimate.

Indicator III: The External Envelope Ratio

There is a significant difference regarding this indicator between the two classes of cities in terms of openings at elevations. Whereas the ratio in Ghardaia is 0.05 which means that openings to outside are practically absent, it goes up to 0.63 in the case of Muharraq where openings are generally screened with wood. The latter ratio is in fact calculated regardless of the screen locally called Mushrabiyya.

This difference could be explained by the opposite requirements in each climatic zone. While in arid zones, heat and glare are the major problems facing human settlements and thus requiring small openings for minimum lighting. High humidity rate in humid regions requires large and opposite openings that speed up cross ventilation.

External surfaces in some cities are also covered with harsh surfaces and thick particles so as to reduce reflection to outside and provide increments of shades to the elevation that might have up to 50% of the total surface shaded (Kaizer T. 1984).

Seasonal and diurnal migration and internal zoning of the home in accordance with the heat dynamics i.e. mode of transfer, change

over time, etc, also provide passive solutions to overcome the undesired effects of climate in these cities. Terraces are in some cities intensively used during night as living spaces, as rooms at the ground level are hot, because of the time-lag. At early morning before sun-rise, the rooms becoming fresher and are used for other domestic activities. This life cycle then radically changes in autumn, where the rooms at night become warmer.

Simulating Compactness

The real results obtained from the analysis above can be proved though a simulation of urban compactness. The shape of the buildings and the assemblage pattern play a primordial role in the thermal performance of the urban forms (Lechner N. 2001:439-441, Markus TA & Morris E.N. 1980:373-375).

The first simulation is concerned with the shape of the building. It consists of demonstrating the preference of the concentric simple forms in buildings on complex, spread-out forms of buildings. Houses that are mostly cubic in form, and inward-looking, provide minimum external shell that is exposed to sun-rays. On calculating a ratio $Y1$, Surface-Area/Volume, that divides the total area of external envelope ($X2$) on the volume of the house form ($X3$), it could be easily seen that the exposure ratio $Y1=K. 1/X$ decreases with the increase of the dimensions of the cube (table 2, figures 2&3).

The second simulation is concerned with the pattern of assemblage of building units that for the urban morphology (table 3, figures 4&5). Compactness could be achieved in its simple form though the grouping of buildings and the

increase of shared walls. In comparison between the dispersed type of urban setting and the compact form, the first one shows that the

number of faces exposed to sun-rays increase exponentially and thus lead to a tremendous solar heat gain.

The Cube Side In a given Unit	External Envelope Exposed to Sun: 5. X2	Volume X3	Ratio of Exposure $Y=K.1/X$
1	5	1	5
5	125	125	1
10	500	1000	0.5
20	2000	8000	0.25
50	12500	125000	0.1
100	50000	1000000	0.05

Table 2: The Decrease of the Surface-Area/Volume Ratio with the Increase of the Size of the Cubic Building Side. (Source: Author).

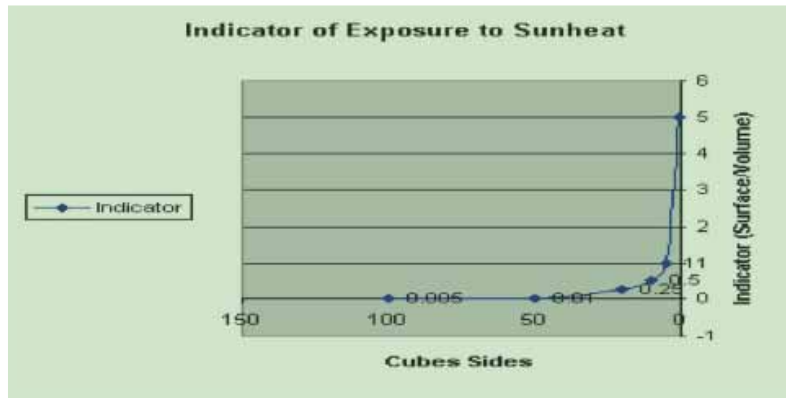


Figure 3: The Relationship between the Size of the Cubic Building and the Exposure to Sun. (Source: Author).

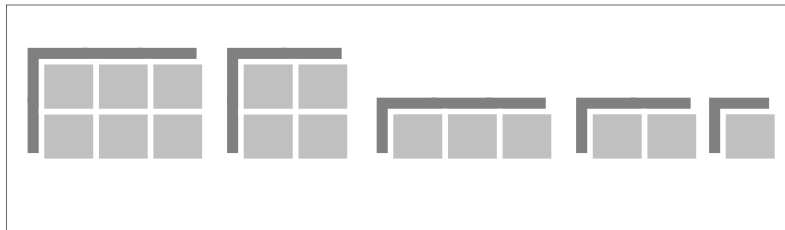


Figure 4: Different Assemblage of Building units showing the Degrees of Compactness. (Source: Author).

Cubes	Number of Faces in a Dispersed Form	Number of Faces in Compact Assemblage
Number of Cubes	Number of Sides in a Dispersed Setting	Number of Sides in a Compact Setting
1	5	5
2	10	8
4	20	12
6	30	16
8	40	20
9	45	21
12	60	26
16	80	32
20	100	38
80	400	100

Table 3: A Comparative simulation of Two Sets of Cubes showing the Exponential Decrease of Exposure to Sun-rays in the Case of Compact Form. (Source: Author).

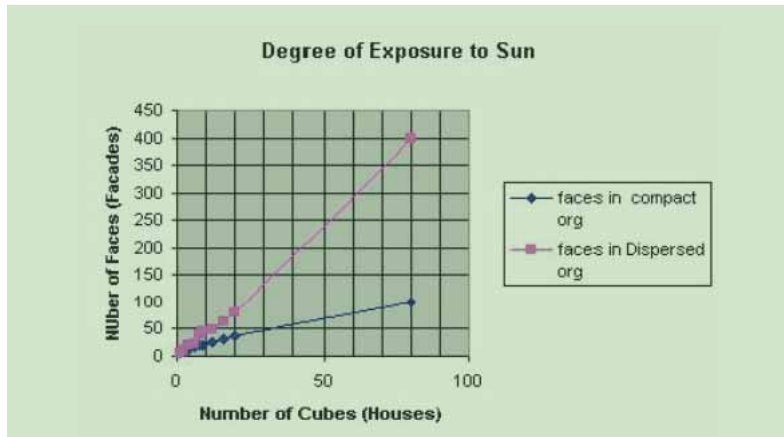


Figure 5: A Graph showing the Difference in the Exposure to Sun-rays between the Two Urban Forms; the Compact and the Dispersed ones. (Source: Author).

Re-Inventing the Compact City

The compact city is increasingly becoming an integral part of a larger new approach to city planning and design which is called new-urbanism. The new movement it has

been undergoing since its birth, firing from the supporters of the present practices. It fails to recognize changing social relations, technological development, and forces of production in modern life (Furuseth O. 1997: 211). It is in other words, criticized as being a

mere re-conduction of the old compact model and is thus, a mere nostalgia and a utopian-romantic vision (Ford L.R. 1999:249).

However, adopting compactness in the post-modern era is becoming more and more acceptable in literature (Burton 2002, Thans 2002). It is based on two strong arguments that are: the growing information technology, and the increasing concern for sustainability (Schroeder et al. 2001, 573-587). To this, the long rooted urban history of city-making, mostly based on the compact model, should be added.

Sections below are based on a model that represents two historical shifts in the form of the city. The first one occurred during the industrialization era from the old compact city, to the modern dispersed city, and the second shift is expected to occur in the information age from the modern dispersed city back to the post-modern compact city. Some promising visions as well as practical aspects for the development of the post-modern compact city through the combination of the concepts of sustainability and IT are stated below.

The Compact City in the Information Age

Information technology is believed to provide an opportunity to release urban planning from car movement, mechanization, and physical constraints of space dimensions and appropriation, and thus rebuilding the new compact city. Most of urban activities that generate traffic (comma removed) could be redesigned in a way to fit the wired city concept, a fact that is taking place gradually through the e-government projects (Reddik C 2004). Rapid growth of web-based applications

on government premises showed significant cost savings through structural changes in productivity and delivery of government information and services (Reddik p2). The project consists of two stages which are information cataloguing, and online transactions building. Three areas are being developed in this concern: the government-to-government (G2G), the government-to-citizen (G2C), and the government-to-business (G2B) relationships. Each stage and relationship is believed to have deep impact on the use of physical space, the city morphology, and its urban dynamics. Trips to pay bills and fees, applications for building permits, commercial registers, banking and financial transactions, passports and other official documents would enormously reduce traffic mass once accomplished through IT networks. Ministries, municipal headquarters, and banks that have long been occupying huge urban spaces, and competing for land in the city centre and in capitals might also shrink to the minimum functional space and be located anywhere in the region once information is stored and accessed digitally through IT connections. Parking places for both public and staff could either be shrunken or eliminated in favour of the virtual world and other ways of mobility and electronic contacts.

Opposite to the XIX century industrial city that sprawled as a result of the mechanical mobility, the city in the information age might witness a back-shift to the compact city due to the rise of other means of communication and new conditions of work. The sprawling phenomenon in this vision might lose its momentum, if networking is exploited to face the disparities between human settlements within the same region, and between the big cities and their

peripheries, through the redistribution of services, goods and job opportunities in the region.

The Compact City in the “New-Urbanism”

Compact city may be better placed in the context of the new urbanism theory. This planning movement that emerged in the USA in the mid-1980's, best known as CNU (Congress of New Urbanism), reflects the strong reaction in the country that most witnessed the development of today's dispersed urban model.

The new movement, despite its short age, as it was officially founded in 1993, is gaining momentum due to the ever-increasing calls that relate environmental degradation, social breakdown and depletion of economic resources to urban sprawl and dispersed forms of developments. Compact city is thus announced, among other principles as a remedy to the cancerous sprawl and suburbia.

On the ground, the CNU has today over 3,100 members in 20 countries and 49 states, that include architects, landscape architects, planners, economists, real estate agents and developers, lawyers, government officials, educators, citizen activists, and students. Though the movement has drawn criticism from much of the architectural academy, the ideas behind CNU's Charter have been gradually integrated into the curriculum at the top planning and architecture schools. In practice, over 210 “New Urbanist” developments under construction or complete in the United States are counted (CNU 2008).

It is evident that physical solutions by themselves will not solve social, economic, and environmental problems, but neither can economic vitality, community stability, and environmental health

be sustained without a coherent and supportive physical framework (CNU2000).

Conclusion

The compact city was the most efficient urban model that traditional communities in the hot regions of Muslim Arab countries developed in response to the harsh climatic agents. At present, compactness is becoming the central theme of sustainable development. The present study approached compactness from the historical standpoint through the analysis of a number of old cities located in the region. The objective was to define practical urban indicators that enable professionals and decision-makers to measure compactness.

The universal shift to information technology that is gradually shaping various aspects of life would have a direct impact on the form of the future city. The compact city that is believed to respond better to ecological and social concerns might find its way to revival in the new information age.

In the light of the movement of new urbanism, compactness is considered as a key word in its new language that guides professionals to good design and planning. Its application embraces all scales of physical environment starting from the region to the block and building level.

References

- Al-Hathloul, S.A. et al. (1975). Urban Land Utilization Case Study Riyadh S.A. Study Report, MIT, Mass., USA.
- Al-Khenaizi, O. (1994). Urban Regeneration of an Arabic Islamic Town: Al-Muharraq , Ministry of Housing, Bahrain.

- Al-Naim, M. (1998). Potentiality of the Traditional House: the case study of Hofuf, AlHasa, GCC Folklore Centre, Doha, Qatar.
- Assis (de) E.S. et al. (1999). Urban Bioclimatic Design Strategies for a Tropical City, Atmospheric Environment, Vol. 33, pp. 4135-4142.
- Bianca, S. (2001). Arab Urban Form Zurich, ETHZ, Switzerland.
- Burton, E. (2002). Measuring Urban Compactness in UK Towns and Cities Environment and Planning B, Planning & Design, Vol 29, pp. 219-250.
- Catalan, B. et al. (2008) Urban Sprawl in the Mediterranean? Patterns of Growth and Change in the Barcelona Metropolitan Region 1993-2000, Landscape and Urban Planning, Vol. 85, pp. 174-184.
- Chan, A.T. et al. (2001). Strategic Guidelines for Street Canyon Geometry to Achieve Sustainable Street Air Quality, Atmospheric Environment, Vol. 35 (24), pp. 4089-4098.
- Chen, H. et al. (2008). Sustainable Urban Form for Chinese Compact Cities: Challenges of a Rapid Urbanized Economy, Habitat International, Vol. 32, pp. 28-40.
- Congress for the New Urbanism CNU (2008). Available online <http://www.cnu.org> Accessed on May 24nd 2008.
- Congress for the New Urbanism (CNU) (2000). Charter of the New Urbanism, McGraw-Hill, New York, USA.
- Crane, R. and Crepeau, R. (1998). Does Neighbourhood Design Influence Travel? Behavioral Analysis of Travel Diary and GIS Data, Transportation Research and Design Vol. 3 (4), pp. 225-238.
- Donnadieu, C. et al. (1977). Habiter le Desert, Mardaga, Bruxelles, Belgium.
- Eben-Saleh, M. A. (2004). Learning From Tradition: The Planning of Residential Neighborhoods in a Changing World, Habitat International, Vol. 28, pp. 625-639.
- Eliasson, I. (2000). The Use of Climate Knowledge in Urban Planning, Landscape & Urban Planning, Vol. 48 (1-2), pp. 31-44.
- Etzion, Y. (1994). A Bio-Climatic Approach to Desert Architecture, Arid Land, Vol. 36, Available online www.ag.arizona.edu/OALS/ALN/aln36/Etzion.html
- Evans, J.M. & Sciller, S. (1996). Application of Microclimate Studies in Town Planning: A New Capital City, An Existing Urban District and Urban River Front Development, Atmospheric Environment, Vol. 30 (3), pp. 361-364.
- Ford, L.R. (1999). New Urbanism and Theories of Good City Form, Cities, Vol. 36 (4), pp. 247-257.
- Furuseh, O.J. (1997). Neotraditional Planning: A New Strategy for Building Neighbourhoods?, Land-Use Policy, Vol. 14 (3), pp. 201-213.
- Garces, J. et al. (2003). Towards A New Welfare State: The Social Sustainability, Principle and Health Care Strategies, Health Policy, Vol. 65, pp. 201-215.
- Golany, G.S. (1996). Urban Design Morphology and Thermal Performance, Atmospheric Environment, Vol.30 (3), pp. 455-465.
- Kaizer, T. (1984). Shelter in Saudi Arabia, St Martin's Press, New York, USA.
- Kilical, A.A. (1990). Vernacular Approach to Climatic Variables in Central Saudi Arabia, Journal of King Saud University, Architecture & Planning, Vol. 2, pp. 99-117.
- Lechner, N. (2001). Heating, Cooling, Lighting: Design Methods for Architects, John Wiley & Sons, New York, USA.
- Li X., et al. (2008). Discovering and Evaluating Urban Signatures for Simulating Compact Development Using Cellular Automata, Landscape and Urban Planning, Vol. 86, pp. 177-186.
- Majed, E.I. (1987). The Traditional Construction of Early Twentieth Century Houses in Bahrain.
- Markus, T.A. & Morris, E. N. (1980). Buildings, Climate and Energy, Pitman, London, UK.

Ministry of Housing, Municipalities & Environment Bahrain (1999). Architectural Features of Traditional Cities in Bahrain , Ministry of Housing, Bahrain.

Olgay, V. (1973). Design With Climate, Princeton University Press, New Jersey, USA.

Pearlmuter D., et al. (1999). Microclimatic Analysis of "Compact" Urban Canyons in an Arid Zone, Atmospheric Environment, Vol. 33, pp. 4143-4150.

Pearlmuter, D. (2000). Patterns of Sustainability in Desert Architecture, Arid Lands, Vol. 47, Available online www.ag.arizona.edu/OALS/ALN/aln47/pearlmuter.html

Reddik, C.G. (2004). A Two-Stage Model for E-Government Growth: Theories and Empirical Evidence for U.S. Cities, Government Information Quarterly, Article in Press. Available online www.sciencedirect.com

Santamouris, M. et al. (2001). On the Impact of Urban Climate on the Energy Consumption of Buildings, Solar Energy, Vol. 70 (3), pp. 201-216.

Schiller, S. & Evans, J.M. (1996). Application of Microclimate Studies in Town Planning: A New Capital City, An Existing Urban District and Urban River Front Development, Atmospheric Environment, Vol. 30 (3), pp. 361-364.

Schroeder, R. et al. (2001). Active Worlds: Geography and Social Interaction in Virtual Reality, Futures, Vol. 33, pp. 569-587.

Scott, K. et al. (2000). From Sustainable Rural Communities to Social Sustainability: Giving Voice to Diversity in Mangakahia, New Zealand, Journal of Rural Studies, Vol. 16, pp. 433-446.

Stanley, B. (2005). Middle East City Networks and the "New Urbanism", Cities, Vol. 22 (3), pp. 189-199.

Thin, N.X. et al. (2002). Evaluation of Urban Land Use Structures with a View to Sustainable Development, Environmental Impact Assessment Review, Vol. 22, pp. 475-492.

United Nations Centre for Human Settlements - Habitat (1997). Monitoring Human Settlements with Urban Indicators, Nairobi, Kenya, Available online www.undp.org/un/habitat/guo/uip.htm

Uthman, M.A.S. (1996). Sudus Village: Archeological and Architectural Study, Dar Al Wafa (In Arabic), Alexandria, Egypt.

Wali, T. (1986). Al-Muharraq: The Development of a Gulf City 1783-1971, Gulf Panorama (In Arabic), Manama, Bahrain.

Whiteford, V. et al. (2001). City Form and Natural Process: Indicators for the Ecological Performance of Urban Areas and Their Application to Merseyside, UK, Landscape & Urban Planning, Vol. 842, pp. 1-13.

Mustapha Ben Hamouche

Mustapha Ben Hamouche holds a Doctorate in Urban and Regional Planning from the Institut Français d'Urbanisme, Paris VIII University, a Master of Philosophy (M.Phil) in Architecture from the Faculty of Arts, University of Newcastle Upon Tyne. He graduated as an architect from EPAU; the Polytechnic School of Architecture and Urbanism, Algiers. In 1986, he joined the University of Blida, Algeria, as an assistant professor, and taught there for nearly 10 years where he was also deputy director of postgraduate studies and research programs. In 1995, he left academia and worked as an Expert-Planner in Town Planning Department of Al-Ain, United Arab Emirates. At present, he is Associate Professor at the University of Bahrain. He published several books and papers in Arabic, English and French on urbanization in the Gulf, urban history in North Africa, the impact of Islamic law on the built environment in traditional Muslim cities, and the application of GIS on Planning and Land-Use in the Arab Gulf cities. His recent focus is on the application of chaos and fractals theory on traditional urban fabrics. He can be reached at mhenhamouche@eng.uob.bh