Aurel von Richthofen

MODELLING LOW-RISE HIGH-DENSITY NEIGHBOURHOODS IN OMAN

The study and critique of the urbanisation expansion process in Oman deemed un-sustainable in large parts, and the derivation of parameters to assess urban expansion patterns and processes, form the base for a model of sustainable urban design. This model is played out on the scale of a residential cluster of 2000 units similar in size to the plan of Al Khoud phase 6. The model results in a volumetric virtual neighbourhood implemented in standard 3D computer-aided design (CAD) programs. It is parametrically conceived, meaning that the previously derived parameters of urban expansion have been translated into meaningful design rules. These rules are comparable to mathematical equations and are referred to as 'shape grammars'.[1] With a given input parameter the CAD program computes shapes that represent buildings, open spaces and streets. This concept can be applied to the urban context where building codes and physical planning standards, but also historical plot lines and ownership determine much of the 'buildable' structures.[2]

These equations as well as the selection of adequate parameters are a choice of the designer and not a predetermined part of the equation. This model can be further localised in response to specific criteria using parametric design software.

URBAN SUSTAINABILITY AS FITNESS CRITERION

Urban sustainability is used as a fitness criterion. The criterion applies to several levels of the parametric design model: 1. On the selection of initial parameters, 2. On the design decisions coded into the parametric equation and 3. As bench-mark or fitness criterion used to assess the resulting geometry. The definition of urban sustainability is built upon a holistic approach to environmental sustainability as described in the UN Millennium Goal 7, and includes sustainable urban design as a key parameter.[3] Density is analysed in detail for Muscat Capital Area using Burchell's characteristics. Urban sustainability can be defined as a framework of social, economic, ecological, physical and political dimensions contributing to a lasting and resourceful urban development.[4]

Urbanisation has a direct impact on society by means of structuring the living patterns of its inhabitants, facilitating certain behaviours and inhibiting others[5]. At the same time the process of urbanisation reflects on imposed conditions that citizens are subject to. Urbanisation can be understood as the expression of a society's inherent cultural values, climatic needs and economic desires. Understood as cybernetic models, urbanisation processes feature feedback loops between the production of urban space and the emergence of societal patterns.[6] In Oman, the impact of urbanisation on the society and the environment is particularly strong, since the development of the city is a very young phenomenon and every Omani is directly involved in the process via a state-sponsored housing scheme.

The model is also built upon the UAE-wide housing concept 'Estidama', developed by the Abu Dhabi Urban Planning Council (UPC) to address rapid growth as part of the 'Plan Abu Dhabi 2030' urban master plan. Estidama, literally translates as 'sustainability', and incorporates many aspects of passive energy efficiency and smart neighbourhoods into an Arab context.[7] While the Abu Dhabi model is the most advanced in the Gulf Region it has not been developed from within the context, but must be considered imported since the underlying frameworks have been applied with little consideration for the local sustainability dimensions above. This also is true for the 'Dubai Green Building Code' and similar regulations.[8]

To date, no model of sustainable urbanisation has yet been developed specifically for Oman, despite its unique characteristics and rapid process of urbanisation.

ASSESSING URBAN SPRAWL AND COMPACTNESS FOR AL KHOUD

To overcome the problem of external application of sustainability criteria one can further translate Burchell's concept of urban sprawl to indicators for Muscat (figure 3.3.1).

All characteristics above can be attributed to neighbourhoods in urban expansion zones in Muscat Capital Area including Al Khoud as seen in the right-hand column. These factors contribute to an accentuated and accelerated form of urban sprawl in Oman. The case-study area is subject to sprawl with all the negative aspects connotated with it. Yet, does the opposite phenomenon of concentration and densification alone yield an answer to the problem for Oman?

Neuman is careful to note, *"an international specification of urban sprawl, while potentially valuable, would need to consider the variability of settlement patterns on the outskirts of cities around the world."* [10] Using this localised sustainability model one can now expand the characteristics of the Compact City developed by Neuman to a matrix of Low-Rise High-Density (LRHD) urban fabric for Oman, since *"these criteria, if applied to a new compact city, will endow it with a degree of functionality. Yet they do not end in themselves, making the compact city sustainable across a full range of parameters."* [11]

It is important to note that urban form on its own cannot solve the problem of sustainable urbanisation. As Neuman states in the Compact City paradox, urbanism suffers from contradicting desires that aim to synthesise both attributes of urban sprawl and compact cities: *"The paradox of the compact city refers to the inverse relation of the sustainability of cities and their livability. For a city to be sustainable, the argument goes, functions and population must be concentrated at higher densities. Yet for a city to be livable, functions and population must be dispersed at lower densities."* [13] To solve this problem, while keeping density as a key criterion, Neuman suggests shifting the attention from form to process.

Figure 3.3.1: Urban sprawl characteristics – Indicators for Muscat.[9]

	Urban sprawl characteristics according to Burchell	***Observed indicators for sprawl in Muscat 2013***
1	*Low residential density*	*Free-standing single-family houses*
2	*Unlimited outward extension of new development*	*Expansion into the Batinah Coastal plain*
3	*Spatial segregation of different types of land uses through zoning*	*Spatial segregation and zoning cemented by Weidleplan Structure Plan of 1991*
4	*Leapfrog development*	*Leapfrog development of major governmental projects leading to insular pockets of development.*
5	*No centralised ownership of land or planning of land development*	*No centralised ownership of land due to redistribution through lottery, lack of land development and monitoring tools*
6	*All transportation dominated by privately owned motor vehicles*	*All transportation dominated by privately owned motor vehicles, no public transport*
7	*Great variances in the fiscal capacity of local governments*	*Hierarchical structure of government authority of land uses among governmental institutions*
8	*Widespread commercial strip development along major roadways*	*Centralised political power in Muscat and various financial actors*
9	*Major reliance on a filtering process to provide housing for low-income households*	*Widespread commercial strip development along major roadways, including shopping malls*
10	*Major reliance on a filtering process to provide housing for low-income households*	*State-sponsored land-allocation system per lottery fosters fast consumption of land.*

Figure 3.3.2: Compact city characteristics – LRHD urban fabric for Oman [12]

	Compact city characteristics according to Neuman	***LRHD indicators in urban fabric for Oman***
1	*High residential and employment densities*	*High and decentralised residential and employment densities*
2	*Mixture of land uses*	*Mixture of land uses*
3	*Fine grain of land uses (proximity of varied uses and small relative size of land parcels)*	*Fine grain of land uses (proximity of varied uses and small relative size of land parcels) on neighbourhood level*
4	*Increased social and economic interactions*	*Increased social and economic interactions*
5	*Contiguous development (some parcels or structures may be vacant or abandoned or surface parking)*	*Contiguous development including traditional agriculture and recreational uses*
6	*Contained urban development, demarcated by legible limits*	*Legible urban development, preservation of past urbanisation, architecture and landscape development*
7	*Urban infrastructure, especially sewerage and water mains*	*Accessibility urban infrastructure, especially sewerage and water mains*
8	*Multimodal transportation*	*Multimodal transportation, encourage shared/soft mobility*
9	*High degrees of accessibility: local/regional*	*High degrees of accessibility and connectivity: local/regional*
10	*High degrees of street connectivity (internal/external), including sidewalks and bicycle lanes*	*High degrees of street connectivity (internal/external), including shaded sidewalks and bicycle lanes*
11	*High degree of impervious surface coverage*	*High degree of impervious surface coverage*
12	*Low open-space ratio*	*Low open-space ratio combined with high floor-are-ratio*
13	*Unitary control of planning of land development, or closely coordinated control*	*Unitary control of planning of land development and management including local participation*
14	*Sufficient government fiscal capacity to finance urban facilities and infrastructure*	*Sufficient government fiscal capacity to finance urban facilities and infrastructure after the oil-based economy*

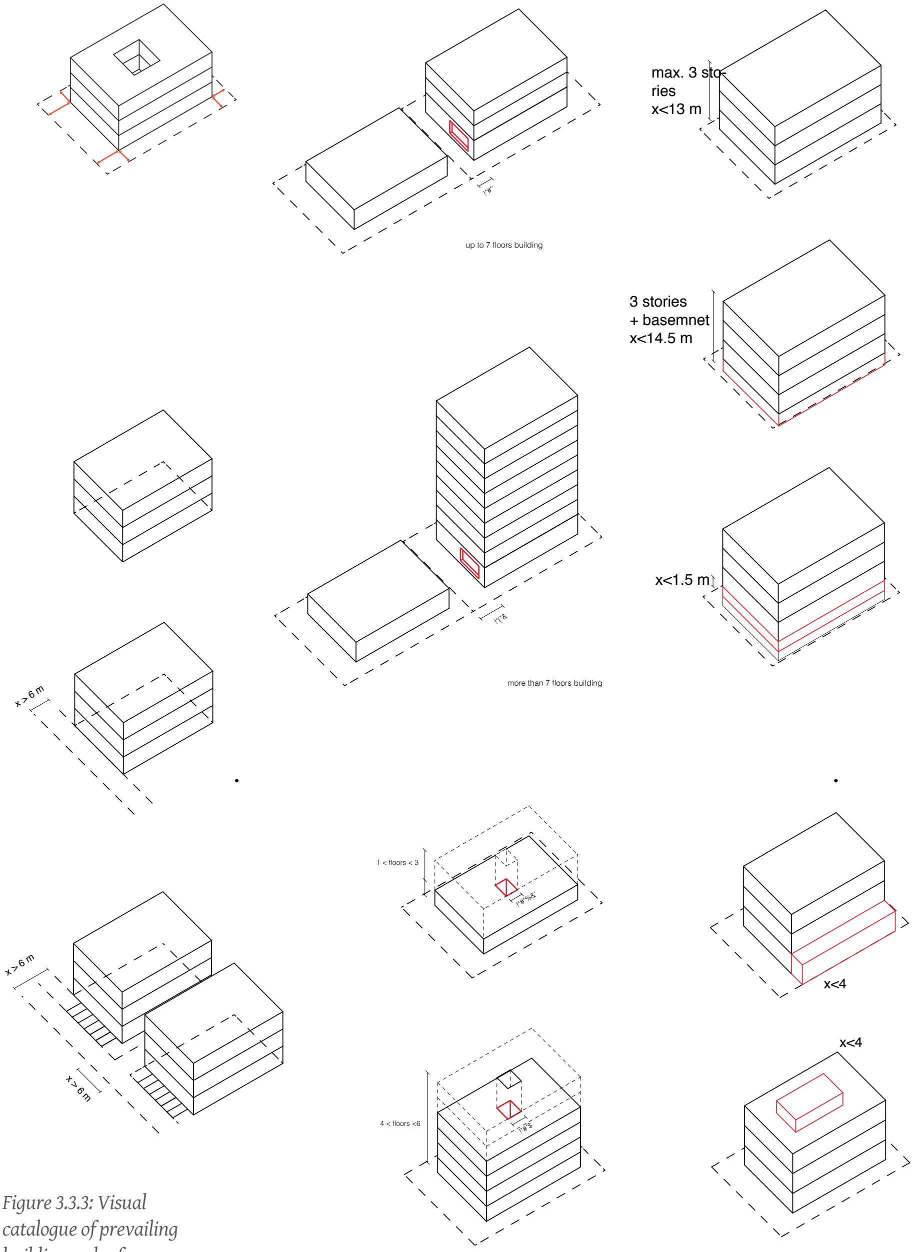


Figure 3.3.3: Visual catalogue of prevailing building codes for Muscat Capital Area

This shift towards processes implies that urban sustainability is never fixed in a single state, hence the inadequacy of the frozen compact form, and, as Durack argues needs to be available *"[...] for open, indeterminate planning, which confers four advantages. First, it supports cultural diversity. Second, it tolerates and values topographic, social, and economic discontinuities. Third, this type of planning invites ongoing citizen participation. Finally, it responds to the state of continuous adaptation, common to all living organisms and systems, including human settlements."*[14] This definition of urban sustainability localised in Oman leads to desired targets and indicators for the urban design model: To create a walkable city, reduce commuting, allow efficient land use, enable low energy consumption, and create social and economic diversity in response to the prevailing sprawl in Muscat Capital Area. Indicators include the distance between daily activities such as residential quarters, schools, shopping and work, road lengths per household, density of the urban fabric, energy efficient buildings, smart urban layouts and mixed-use neighbourhoods including climate-responsive cities with local identity.

MODELLING LOW-RISE HIGH-DENSITY NEIGHBOURHOODS

The prevailing building codes have been studied for aspects directly related to the categories of density, access and public space and translated into diagrams explaining set-back rules and building heights. An illustrated building code gives direct visual understanding of the underlying driving forces fostering a certain type of urbanisation. A LRHD Neighbourhood for Oman is a response to urban sprawl. It can be measured against the targets and indicators. A courtyard type house has been chosen as Basic Building Unit. This house occupies a 15 x 20 m plot (300 m^2) representing exactly half of the plot size currently allocated to by the governmental lottery system to all adult Omanis. This reduced plot size offers nonetheless the same floor area of approximately 310 m^2 by using a denser building typology. It also offers a locally adapted typology with a 'majlis' (guestroom) in the front and the desired privacy in form of a courtyard to the back. Public and family functions can be easily separated. The 15 x 20 m plot can be segmented into six parts of 5x5m. Four of these six segments can be built up with an average of two floors. By shuffling the four elements over the six possible parts a catalogue of expansion possibilities can be produced. This Basic Building Unit utilises passive means of energy preservation: Solar collectors for hot water and electricity production, efficient insulation materials, reflective roofs to reduce the solar heat impact, use of low-impact local materials, natural lighting from the roof, water-efficient landscaping for outdoor shading, optimal orientation of house and openings facing West.

The Basic Building Units can be assembled in small clusters. These groups of houses will provide shade and create narrow, naturally shaded and ventilated Sikkas (pathways). The size of the clusters is determined by a maximum distance of 80 m considered walkable under the climatic conditions in Oman. Cul-de-sacs roads penetrate the neighbourhood, but prevent through traffic. This ensures priority of pedestrian mobility. Several clusters form a Barahaat (neighbourhood), where streetscape and building footprints form an intricate and intertwined urban fabric. Public spaces, small shops, schools and mosques are located around multiple centres throughout the neighbourhood. Arterial green strips fed with recycled grey water complete the LRHD Neighbourhood.

IMPLEMENTING LRHD IN OMAN

The mechanisms of current urbanisation can be geared towards a more sustainable, inclusive and adaptable process with a parametric model for LRHD Neighbourhoods. The model provides variable alternatives to the present conditions in form of qualifiable and quantifiable urban morphologies. The resulting parametric model is comparable to a digital design manual: It focuses on process over form for sustainable urbanisation in Oman. Simulation can take place on a building unit, neighbourhood unit or urban scale. The model constantly updates the geometric layout, and by virtue of an attached database, all relevant factors relating to density, access and public space as digital data.

The LRHD Neighbourhood designed for Oman covers an area of 1 x 1 km. This area is then sampled for indicative figures relating to density, access and public space, such as the sum of building areas, plot areas, circulation areas, green areas and void spaces in comparative studies of neighbourhoods in

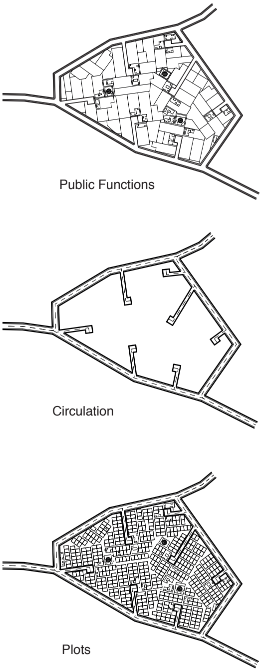
Muscat and the Gulf Region. The sample area is also parsed to establish a sustainability profile compiling relevant numbers (plots, inhabitants, cars, etc.), lengths (road length), areas (open, covered, green spaces, building footprints, circulation areas, etc.) and ratios (floor-area ratios, built-up area ratios, parking-area ratios, circulation length ratios, etc.). This catalogue establishes a sustainability benchmark for Muscat Capital Area.

EVALUATING LRHD MODELS

The LRHD Neighbourhood model has been tested for one set of premises only. Due to the complexity it was only possible to evaluate one Basic Building Unit (courtyard typology) applied to the urban expansion case study in analogy to Al Khoud. The model offers a valid solution with excellent results in comparison to the currently prevailing conditions. The initial decision to reduce the plot size by half has further impact across the model and leads to twice the number of building footprints on a comparable neighbourhood site. The average footprint area is slightly more efficient in the LRHD Neighbourhood model due to efficient land use. This effect is more accentuated across all the ratios evaluated: For example, Floor Area Ratio (FAR) is almost three times as efficient. The circulation area remains the same while the LRHD Neighbourhood offers twice as many homes as the reference case study Al Khoud. The road length per inhabitant is about one quarter in the LRHD Neighbourhood. Additionally the LRHD Neighbourhood offers green and shaded outdoor spaces.

The LRHD Neighbourhood is a planning model and an evaluation tool at the same time. The neighbourhood can be planned and implemented holistically. It is a co-ordination and communication tool between various stakeholders. A change in the current land allocation system is not necessary to implement this model but a control mechanism for the actual development of the land and a land-management system need to be implemented. LRHD Neighbourhoods could alleviate the land allocation dilemma that offers a 600 m^2 plot of land to all Omanis age 23 and above but has more and more difficulties finding adequate plots to distribute.[15] It could also offer a social and culturally responsive alternative to the isolated and car-dependent life-style patterns currently visible.

Energy-related and economic aspects can also be integrated if linked to Building Information Models (BIM). These findings would underline the importance to act now and create locally adapted LRHD Neighbourhoods for Oman. The model is both a tool to analyse, assess and visualise parameters derived and to design locally adapted sustainable neighbourhoods. It offers the possibility to play through a series of similar scenarios resulting from changes in the initial parameters. The model also offers immediate visual feedback to a larger public and can be queried by engineers, architects and planners for a range of quantitative data.[16] The model allows designing LRHD sustainable neighbourhood for Oman.



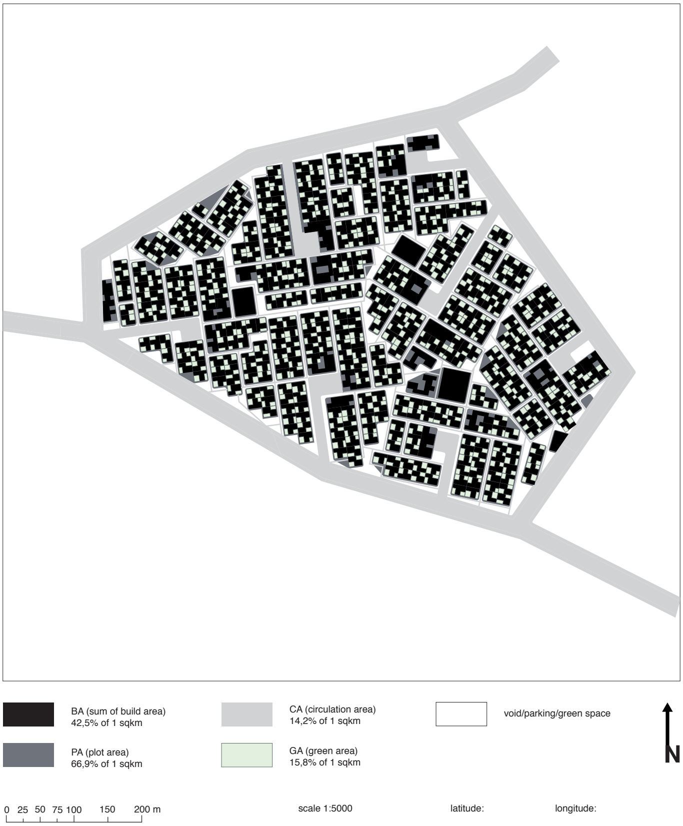


Figure 3.3.4: Generative diagram LRHD neighbourhood model

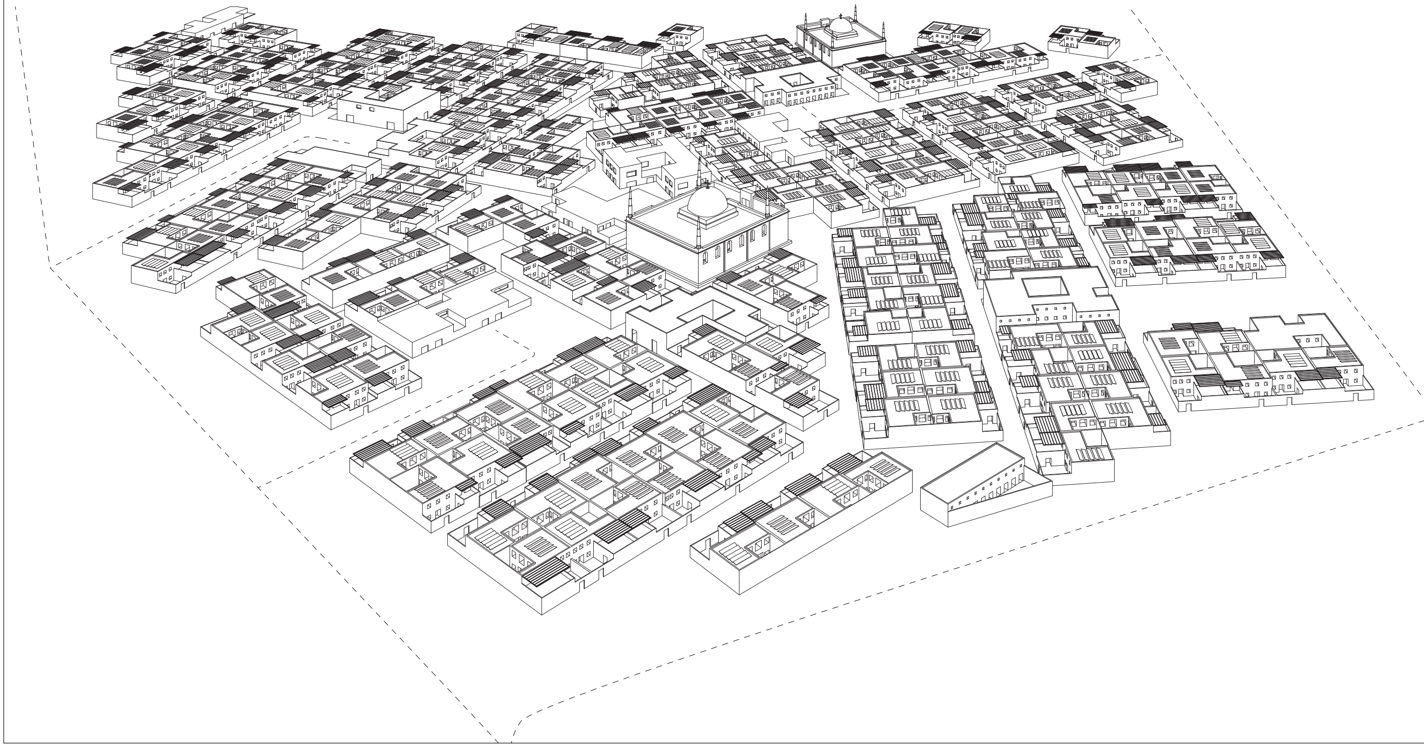


Figure 3.3.5:
Visualisation LRHD
Neighbourhood

NOTES

1. James Gips, “Computer Implementation of Shape Grammars,” in NSF/MIT Workshop on Shape Computation, 1999, http://www.shapegrammar.org/implement.pdf
2. José P. Duarte, João M. Rocha, and Gon\ccalo Ducla Soares, “Unveiling the Structure of the Marrakech Medina: A Shape Grammar and an Interpreter for Generating Urban Form,” AI EDAM-Artificial Intelligence Engineering Design Analysis and Manufacturing 21, no. 4 (2007): 317–50
3. “United Nations Millennium Development Goals,” Goal 7: Ensure Environmental Sustainability, accessed June 3, 2014, http://www.un.org/millenniumgoals/environ.shtml
4. Adriana Allen, “Sustainable Cities or Sustainable Urbanisation?,” Palette - UCL Journal of Sustainable Cities, 2009, www.ucl.ac.uk/sustainable-cities
5. Christopher Alexander, Sara Ishikawa, and Murray Silverstein, A Pattern Language: Towns, Buildings, Construction (Oxford University Press, 1977)
6. J. Beirão, P. Nourian, and B. Mashhoodi, “Parametric Urban Design: An interactive Sketching System for Shaping Neighbourhoods,” in Proceedings of the Conference eCAADe, 2011, http://repository.tudelft.nl/view/ir/uuid:23079c5f-d0ea-40e1-af1c-800c85b294c0/.
7. Abu Dhabi Urban Planning Council (UPC), “Estidama,” accessed April 27, 2015, http://estidama.upc.gov.ae/estidama-and-pearl-rating-system.aspx
8. I refer to Abu Dhabi 2030 Vision, Green Dubai Guidelines 2010 in particular as leading urban planning frameworks and eco-guidelines released since 2010 in the region: Abu Dhabi Plan 2030 - Urban Structure Plan and Dubai Municipality. Green Building Regulations & Specifications, 2013
9. Based on: R. W. Burchell et al., The Costs of Sprawl - Revisited (National Academy Press, 1998)
10. Neuman, “The Compact City Fallacy,” 15.
11. Ibid. 15.
12. Table 2: R. W. Burchell et al., The Costs of Sprawl - Revisited ., 14. Table 2 extends the list of characteristics of the compact city developed by Neuman that he suggests to be”used to guide future research. This preliminary and not exhaustive list suggests variables that can be tested in future research. The characteristics in Table 2 are based on reviews of practice, research, literature, and observation.”
13. Neuman, “The Compact City Fallacy,” 16.
14. Ruth Durack, “Village Vices: The Contradiction of New Urbanism and Sustainability [Portfolio],” Places 14, no. 2 (2001), http://escholarship.org/uc/item/4667g41s.pdf
15. Ministry of Housing Oman, Land Allocation by Lottery - Awarded Plots in Oman during 2009, 2009, http://eservices.housing.gov.om/arb/Pages/Statistics.aspx
16. Steve Gibson and Stefan Müller Arisona, eds., “Live Visuals for Performance, Gaming, Installation, and Electronic Environments,” in Leonardo Electronic Almanac (LEA), Special Issue (MIT Press, 2013)