DESIGNING SUSTAINABLE NEIGHBORHOOD TYPOLOGIES FOR NATIVE HOUSING IN ABU DHABI

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Abstract
This project focuses on achieving higher levels of environmental, economic, and socio-cultural sustainability among native neighborhoods in Abu Dhabi. Having some of the world’s largest ecological footprints, highest rates of urbanization, and lowest bio-capacities, Gulf Cooperation Council (GCC) cities must begin transitioning to more sustainable practices. Abu Dhabi and the United Arab Emirates seek to be front runners in this process by supporting research that focuses on urban sustainability. Within this context, this project aims to develop a comprehensive design methodology which operationalizes theory and numeric analysis towards multi-criteria assessment and iterative, feedback-driven design of new neighborhood typologies. In contrast with existing design approaches, the project conceives of sustainability as the combination of qualitative and quantitative factors and metrics reflecting the Emirati’s socio-cultural practices, their economic conditions, and the region’s environmental and climatic limitations.

The first phase of the project focuses on the definition of a theoretical base through an extensive literature review and analysis of existing conditions. This includes research on the concepts of urban sustainability and urban form in the specific GCC context, basic calculations and modeling of existing household and neighborhood metabolism, mapping of the historic evolution of Abu Dhabi’s urban form, analysis of the existing planning frameworks and urban policy, and study of precedent cases. This phase will yield sustainability indicators and metrics for Abu Dhabi that will be used as a base for later stages of the project. The second phase will include the development of a digital toolkit that measures and models the metabolism of existing neighborhoods and aids the development of sustainable design typologies. Through an iterative process, using the digital toolkit and the sustainability indicators, design solutions will be developed for retrofitting existing neighborhoods and building new ones with a focus on socio-cultural, economic and environmental sustainability. The third and final stage will involve the development of strategic implementation methods for sustainable neighborhoods that streamline with current policy initiatives.
INTRODUCTION

Drivers for change: Why is this needed?

The United Arab Emirates is a member of the Gulf Cooperation Council (GCC), a group of countries in the Arabian Peninsula. The GCC is 80 percent urbanized and will be home to fifty-three million people by the year 2020. The GCC itself is situated within the Middle East and North Africa (MENA) region which, broadly speaking, shares a climatic and religious context, and while home to 6 percent of the world’s population, controls 60 percent of the world’s oil resources. Since the 1960s, the wealth created from oil exports has driven rapid urbanization and population growth within the GCC cities. This development has been guided predominantly by Western modernist planning principles. Their development models have favored the automobile to connect low-density, residential superblocks and neighborhoods across an ever expanding urban fabric. This rapid expansion of modernist forms has left little scope for the natural evolution of climatically responsive and culturally appropriate vernacular typologies. The result is neighborhood typologies which are both environmentally and socially unsustainable, a condition exacerbated by the region’s hot-humid climate, its hyper-aridity, and the subsidization of electricity and water usage by governments. Combined, these factors result in some of the highest per-capita resource usage rates and GHG emissions globally, with the UAE consistently having among the top three largest per capita ecological footprints in the world. In fact, energy demand is growing so rapidly that Abu Dhabi can’t produce enough electricity from domestic and regional sources of gas, and is turning to nuclear and coal in response. There is, therefore, an urgent need to rethink the urban form paradigms that are guiding urban development in the region.

Many of the GCC countries have recently recognized this need and initiated efforts for making sustainability central to their urban agendas. Abu Dhabi’s government has recently established the Urban Planning Council (UPC, set up in 2007), the Department of Municipal Affairs (DMA, set up in 2007), and the Abu Dhabi Housing Authority (ADHA, set up in 2012). Out of these agencies have come the Plan Abu Dhabi 2030, the Abu Dhabi Urban Structure Framework Plan, and the Pearl Rating System and Estidama program for sustainability. Furthermore, the government has begun efforts to measure resource usage at the household level to set a base-line for consumption data.

While these are important efforts at the governmental level, there is still much left to be done within the academic realm, where research and theorization are lagging behind. The literature on urban form and its growth, and urban metabolism in the GCC region – and in Abu Dhabi in particular – is limited compared to other regions such as Europe, North America, and many parts of Asia. This project is needed, in part, to establish a baseline analysis of the urban form and its resulting metabolism in Abu Dhabi. Then, from this research, new designs for more socially and environmentally sensitive typologies, as well as for new governmental policy, can begin.
To properly assess these new urban patterns, the project will also develop tools for quantified analysis and design feedback which foregrounds the specific environmental and socio-cultural needs of the region. The team will also address the existing gap in urban research to spatialize specific socio-cultural needs and translate them into a series of physical forms and elements that can be fed into a digital module for dynamic modeling. The various tools will work together to simulate trade-offs between varying levels of environmental and socio-cultural sustainability, allowing for real-time design decision making. Research must also examine the unique potential of solar energy in the region, where projects have recently underbid the cost of natural-gas based energy production. In short, the water-energy nexus, and solar potential of the GCC and MENA region at large have not had the appropriate computational or analysis tools developed to allow for design optimization and new typological development.

**General Approach on Methodology**

The project will be developed through a series of iterative phases. These are:

- Analysis of existing conditions and review of literature on: (A) Sustainability and sustainable urban form in the GCC region (environmental, economic, socio-cultural); (B) Urban metabolism of existing households and neighborhoods including measuring and modeling building energy, water use, mobility, waste output and GHG emissions; scales at which different metabolic activities operate; and interrelationships between flows and processes; (C) Interrelationships between urban form (e.g. density, diversity, dynamic interaction between landscape, infrastructure, and built form) and neighborhood metabolism; (D) Local urban form and its development through history; (E) Priorities of the government set forth in planning policy documents; (F) Global and local case studies; (G) Sustainability indicators, metrics, and target levels – quantitative and qualitative;
FIGURE 3
Urban Growth of Abu Dhabi
Dates: 1960 to 2015
Source: Authors, GIS data
Existing digital modeling and simulation tools for measuring and designing for sustainability

- Development of a digital toolkit to: (A) Measure levels of sustainability of existing neighborhoods based on metrics developed in phase 1; (B) Design sustainable retrofitting measures for selected existing neighborhoods; (C) Design new sustainable neighborhood typologies

- Development of strategic implementation methods, including: (A) A policy toolkit that aligns with ongoing efforts by the UPC and ADHA to facilitate potential implementation of design typologies developed in phase 2; (B) Strategic methods for adoption of the digital toolkit for long-term development of sustainable native neighborhoods in Abu Dhabi and the region

Deliverables: Designs of new and retrofitted neighborhood typologies, policy toolkit and implementation strategies

Background and Purpose of this Document + Intended Audience

The project is intended both as an academic exploration and a practical effort aiming to improve existing planning and design methodologies in the wealthy cities of the Arabian Gulf region, and propose implementable design strategies for sustainable urban form of native neighborhoods. The project is a part of the ongoing MIT-Masdar Institute Cooperative Program between the Institute Center for Smart and Sustainable Systems (iSmart) at Masdar Institute in Abu Dhabi, UAE, and the Center for Advanced Urbanism at MIT in Cambridge, MA, USA.

The publications developed through the course of this project are intended for a wide range of members of the urban community, including, (a) the urban governmental agencies in the GCC cities that can potentially use the research to implement sustainable native neighborhoods; and (b) academics and professionals interested in:

- The emerging field of research based design
- Sustainable urban form in desert, hot-humid, wealthy, and rapidly urbanizing Arab cities
- Modeling and simulation of urban form at a neighborhood scale in a comprehensive way

CURRENT CHALLENGES & OPPORTUNITIES

Conceptual Urbanism Challenges & Opportunities

Globally, sustainability, as a concept, is interpreted in multiple ways. Most scholars and professionals agree that urban sustainability is a growing and urgent need that should be addressed at local, regional and global scales. However, the vagueness of the definition of sustainability,
along with open ended assessment methods, makes it difficult for the concept to be substantially understood and addressed.

Additionally, sustainability needs to be addressed at both the local and global scales. Since most of the GCC cities have urbanized recently, there is limited academic literature available on the urban form and the issues of sustainability specific to the region. The project team aims to use this opportunity to develop a contextual and operative definition for sustainability in arid regions such as Abu Dhabi, and develop metrics that can effectively measure and report levels of sustainability to aid development efforts in a holistic manner.

Literature reveals that most academic research done on global urban sustainability has been focused either on the building level or on the city or regional level. However, in historic Islamic cities, in Abu Dhabi’s modernist urban history, and the various contemporary urban planning documents prepared by the UPC, the neighborhood is the critical urban unit. Additionally, since the neighborhood is the unit at which most cities get planned, constructed, and experienced, the project aims to address sustainability primarily at the neighborhood scale, for which there are limited precedents.

In Abu Dhabi, almost all native neighborhoods are composed of a relatively homogeneous building typology – the one to three story detached villa. This typology, imported from Western contexts in the 1950s, departs majorly from the vernacular Arab courtyard house that has been studied extensively by academics for its environmental and socio-cultural appropriateness. Initiated by oil companies for employee housing and propagated by government housing schemes and regulations, the villa has now become the preferred form of native housing, equated with economic stature and comfort. This presents a larger challenge to address the cultural associations of villas with progress and modernity, and the concurrent association of courtyard houses with a sense of retrogression.

Holistically, there is a timely opportunity for this project to create housing typologies for Abu Dhabi natives that are environmentally, economically, and socio-culturally sustainable, through an iterative process of modeling native housing form using a combination of contextual qualitative and quantitative metrics.

To tackle the more conceptual challenges mentioned above, some of the questions that the project aims to address are:

- How do hot-humid, desert regions, with extremely limited natural capacity, urbanize rapidly while maintaining a low ecological footprint?
- At what scale can we best measure and design for urban sustainability needs?
- How, if at all, can Western planning and design models be implemented in Arab cities while being reflective of local culture?
- How can the vernacular and the concept of sustainability be meaningfully integrated in planning capacity, process, and governance in upcoming cities?
Organizational and Institutional Challenges

The process of urban planning in Abu Dhabi, as in most other GCC cities, is almost entirely top-down. This approach allows for relatively efficient planning and implementation of large scale urban projects due to limited bureaucratic involvement. However, it leaves less scope for public engagement and the incorporation of cultural necessities and social perceptions into the design and planning process. The allocation, design and construction of native neighborhoods is through public-private partnerships. Designs are governed by factors such as the real estate market, and the idealism of the ‘global city’. In many cases, this has led to the needs and aspirations of the local communities becoming peripheral to the design process.

Since its establishment in 2007, the UPC has developed and implemented a multitude of planning and design guidelines. One of the biggest criticisms of these documents has been their over-prescriptive quality without clear directions for implementation. This issue has been compounded by the lack of coordination between the various urban agencies. In addition, due to limited local capacity, most of the planning paradigms applied in Abu Dhabi have been imported from other parts of
the world, with Vancouver and Singapore being two of the aspirational cases. This has led to the disappearance of or the transformation of the vernacular into a purely aesthetic feature.

Logistically, access to data is a major challenge. In many cases, detailed data that has been collected by various public agencies exists, but is inaccessible to the public or academic institutions, which limits research capacity.

ADVANCED URBANISM MODELS

Principles/Theories that Make the Approach “Advanced”

The project aims to develop a comprehensive design methodology which operationalizes theory and numeric analysis towards multi-criteria assessment and iterative, feedback-driven design of new neighborhood typologies. In contrast to existing design approaches, the project conceives of sustainability as the combination of qualitative and quantitative factors or metrics reflecting the Emirati’s socio-cultural practices, their economic conditions, and the region’s environmental and climatic limitations. The project further aims to develop models and tools which, (a) afford designers

FIGURE 5
Water-Energy Nexus in Abu Dhabi
the ability to compare existing typologies, retrofits to those typologies, and new prototypes on similar terms, (b) provide intuitive interfaces for inputting required data-sets, parameters, and geometries, and writing out the resulting output metrics, (c) can be augmented with genetic-solvers and other tools which aid in searching system boundaries and thresholds towards single or multi-variable optimizations (d), allow for the projected effects of changing future technologies, governmental policies, and resource prices. Ultimately, the project aims to connect the effects of urban form, urban systems, new technologies, economics, and human behavior on neighborhood metabolism and prevalent socio-spatial practices.

Precedents

Precedents – both projects and literature – will be selected based on their efforts towards achieving sustainable urban form, and measuring and modeling neighborhood metabolism. Precedents for sustainable urban form will include global and local cases where cities or neighborhoods have been designed with sustainability as one of the foci, and urban policies have been formulated to incentivize sustainability among urban communities. Precedents for neighborhood metabolism will include literature on studies conducted to measure and model neighborhood systems and flows as they relate to sustainability and urban form.

Cases will be studied to understand ways in which they have tackled sustainability both at design and policy levels, the hurdles encountered by them, levels of success and ways to measure it, lessons learnt, and ideas generated through the process. Through a process of curation, these cases will be analyzed to derive learnings that are contextually appropriate and applicable.

Project Vision and Goals

The Strategic Vision of the project is bipartite – it aims to develop an operative, theoretical base for work on sustainable urban form in Abu Dhabi; and using this base it aims to develop new forms of native neighborhoods...
that are sustainable environmentally and economically, and align with the cultural and social norms of the local population.

Project goals include:
- Creation of a substantial base of literature and graphics defining the language of native residential urban form of Abu Dhabi including documentation of historic evolution, policy initiatives, planning influences, etc.
- Operationalization of the definition of sustainability and its metrics for hot-humid and arid regions such as Abu Dhabi
- Development of a basic native neighborhood metabolism model to measure resource inflows and waste outflows
- Ideation and generation of innovative sustainable housing typologies that are economically, environmentally, socially and culturally appropriate through dynamic digital modeling
- Generation of strategies for implementation of these housing typologies within the existing political framework

Implementing the Strategic Vision

Being an academic collaboration, the project is intended to be a theoretical and analytical exploration with recommendations for strategic implementation within the existing policy framework. It aims to undertake an extensive process of iteration and testing to develop sustainable ways to retrofit existing neighborhoods and develop new ones. Scenarios will be tested at multiple scales to simulate a varying set of interactions and forms, including:
- Neighborhood typologies
- Edge conditions between neighborhoods
- Block typologies
- Plot typologies
- Growth/Expansion patterns at the city scale

Since the project aims at developing sustainable typologies both for retrofitting existing neighborhoods and developing new neighborhood forms, the proposed solutions can, in theory, be piloted in existing neighborhoods, such as Khalifa A, Al Falah, etc., and in locations which have been stipulated as sites for new neighborhoods in the planning documents, such as the Capital District. All native neighborhoods will be analyzed through the project process using the parameters developed in the analysis phase. Based on these, the specific neighborhoods for pilot interventions will be selected and categorized by their current levels of sustainability and the potential for their respective urban forms to be receptive to adaptations for increased sustainability.

The existing governance of the native housing allocation and construction process lends itself to the development of a relatively streamlined process to facilitate implementation of new design typologies for native neighborhoods. For implementation of new typologies by policymakers, digital simulations of various economic tariff models and other
policy initiatives can be developed to conduct real-time feasibility studies of the proposed design typologies, specific to proposed sites. For sustainable design, a neighborhood sustainability toolkit can be developed. This toolkit can include guidelines and digital tools that will allow architects and real estate developers to design new neighborhoods and retrofit existing neighborhoods to achieve maximum possible levels of sustainability. The toolkit can also contain digital tools to facilitate community engagement, which can be used by policy-makers and designers to learn about and understand priorities of the natives and increase the potential levels of social sustainability in the neighborhoods.
Endnotes

1 Bahrain, Kuwait, Saudi Arabia, United Arab Emirates, Oman, and Qatar.


3 https://en.wikipedia.org/wiki/MENA

4 Riyadh, Baghdad, Kuwait City, Dubai, Abu Dhabi, and Doha all follow the same superblock principle.


