Optimising sustainability at an urban level: a case study of Dubai Sustainable City

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Abstract

With the growing interest in sustainability and sustainable design both regionally and globally, there emerged the challenge of designing and constructing a sustainable community in the desert, which invited some interesting ideas. One of these was Dubai Sustainable City, with climate and environment influencing its design. The UAE and Dubai in particular are trying to set a reference benchmark when it comes to sustainable design in such harsh climates. The aim of this study is to assess a sample case study of a new sustainable urban settlement from this region (*Dubai Sustainable City)* through a comparative analytical study of the chosen project (*Dubai Sustainable City)*, a comparative study (assessment: LEED) which is held between the existing design and the same – but yet enhanced – design after applying the research recommendations. Some of the points that were raised – besides the sustainability of the design itself – through a practical approach were health, social life and the liveability of the current project design. Whilst this paper mainly focuses on the UAE's sustainable developments, it could be argued that many of the research outcomes are of relevance to other countries and regions, especially those with the same social and harsh environmental conditions as the UAE.

Keywords: sustainability, design strategies, land use, adjustments capacity, transportation, sustainable landscape, CityCAD, master planning, sustainable communities, urban design.

1 Introduction

Architecture is an intensive experience of complexity, elements, strength, joy, concepts, expressions, structures and mechanical designs, always complex and

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contradicting and working on a macro scale of urban design adds to the difficulties [1].

Sustainability is today's major global concern and comes from a global instinct for survival. First, and of huge importance, are the three-Rs' strategies: Reduce, Reuse and Recycle. Urban communities contribute in terms of resource consumption in the sense that they are a group of individual buildings where people live and interact in – and with – waste production. This is where there is a necessity that architecture and urban design must offer solutions for human beings to sustain living. This study takes the realistic approach of case study analysis of Dubai Sustainable City and analysis of existing site data. It is divided into three stages: understanding (analysis of existing conditions); exploring (documenting the charrette and filling materials) and deciding (preparation and presentation of the report). The feasibility of future guidelines for greater sustainability will take the outcomes to the next level of retrofitting and enhance the current project's urban sustainability.

2 Literature review

The current environmental crisis, declining resources, economic uncertainty, increased population and global urbanization is propelling the world towards sustainability as a necessity. The idea of sustaining a way of life or economic and social wellbeing is as old as humanity. What is new in the idea is scientific knowledge that our planet's humanly habitable space is shrinking and that stable ecosystems and biodiversity are under threat from both global climate change and human activity. Human perception does not yet seem to have recognized the enormity of these problems as the parts affect the whole in a co-evolutionary synergy. Concentrated urban populations draw heavily on water, energy and other resources, while producing equally heavy amounts of waste. This should be considered in relation to larger concepts of sustainability, including equitability and ecological concerns [2].

Other definitions point to seeing the world as a system that connects space, place, and time within a single interconnected planet. Therefore, big changes are needed immediately, but still remain more ideals than realities [3].

Other elements of architectural and urban environments – such as public spectacle – are discussed in Venturi's second influential book *Learning from Las Vegas* [4] and may have challenged public acceptance of sustainability, but under very different circumstances. Today, despite the continued popularity of Disneyland, Dubai land and Las Vegas, the city of spectacle must consider how to maintain urban attractions while reducing costs and consumption of water and energy and production of waste [2]. Urban spaces and individual buildings contribute enormously to resource consumption and waste production.

3 Methodology

3.1 Design methodology and approach

This paper combines a literature review, site visit and analysis. Empirical data was collected through interviews with key personnel and data from developers. Formal, structural and technical design elements were examined, compared and contrasted in a comparative analytical study. The intention was to establish a foundation for the restructuring of the current Dubai Sustainable City.

Various properties were summed up using CityCAD, discussed and concluded in order to determine the basis of a sustainable community. These included land use, roads and infrastructure, building materials, landscape and vegetation, accessibility, a car free environment, renewable energy implementation and social sustainability.

4 Case study

4.1 Location

Dubai Sustainable City is located in a remarkable location; it is 15 minutes from downtown Dubai, 20 minutes from Dubai International Airport, and10 minutes from Al-Makttoum airport and the World Expo 2020 Location (Diamond Developers, 2014).

4.2 Existing design

Dubai Sustainable City's designers aimed to present to Dubai a project of a kind that adopted sustainable urban design settings, making this city a regional leader in eco-tourism alongside environmental protection and awareness. It features 500 townhouses and villas, an eco-resort and environmental design institute, all of which are served with a wide range of facilities and occupies almost 46 hectares of land. The city is designed to accommodate 2,700 residents along with a daily population of 6,000, producing 10 MW peak solar production of energy as well as supplying all its residents with organic food from its farms and bio domes. Residents will use their private vehicles on a ring road surrounding the city to centrally located, PV covered, parking lots that are 90 meters walkable distance from the furthest villa; from there they can walk or take the electric carts provided by the city itself (Diamond Developers, 2014).

4.3 Analysis

4.3.1 Overview of existing design

Total built up area	5203
0.44 sq km	Total energy use
Total green space	23288 kWh/day
0.07 sq km	(8500000 kWh/year)
Estimated population	Total parking spaces 3025 total

Vehicle trips	585/day	Retail GFA	87194 sqm
Residential GFA	68037sqm	No. of shops	50
Number of dwellings	530	Other GFA	239991 sqm
Residential population	2863		
Office GFA	13333 sqm		

4.3.2 Land use summary

Shops (A1)	39627	sqm (9.7%)
Financial/professional services (A2)	528	sqm (0.13%)
Restaurants and cafes (A3)	6235	sqm (1.53%)
Hot food takeaways (A5)	1056	sqm (0.26%)
Business (B1)	13333	sqm (3.26%)
Storage and distribution (B8)	528	sqm (0.13%)
Hotels (C1)	25893	sqm (6.34%)
Dwellings (C3)	10563	sqm (2.59%)
Health service (D1)	1866	sqm (0.46%)
School (D1)	23487	sqm (5.75%)
Other institutions (D1)	66265	sqm (16.22%)
Assembly and leisure (D2)	6563	sqm (1.61%)
Other use	5449	sqm (1.33%)
Semi-detached or detached housing	57474	sqm (14.07%)
Open space – playground	3185	sqm (0.78%)
Open space – sports and recreation	21310	sqm (5.22%)
Open space – park	4319	sqm (1.06%)
Open space – managed green area	66417	sqm (16.26%)
Open space – car park	54455	sqm (13.33%)

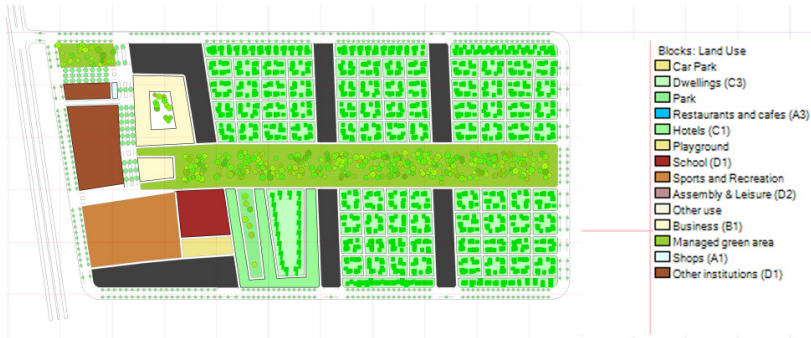

Figure 1: Land use analysis (CityCAD).

4.3.3 Residential summary

Semi-detached or detached housing	530 units
Total:	530 units
Total residential units (existing group)	530

4.3.4 Liveability analysis

Net residential density	1500.79 dw/sq km		
Residential population density	8104.26 ppl/sq km		
Average dwelling size	128.31 sqm		
Average habitable room size	31.63 sqm		
Approximate public realm density	28.69 sqm/person		
School provision	2340 spaces		
Green space per person	14 sqm/person		
Total number of trees	482		
Average number of parking spaces within 5-mins walk			2174.8
Average number of parking spaces per residential population			1.06
Average population per entrance		32 ppl/entrance	
Average distance from dwellings to:			
Green space	96 m	Convenience store	423 m
Health service	369 m	Bank	423 m
Education	382 m	Pharmacy	423 m
Parking space	75 m	Supermarket	423 m
Shops	244 m		

4.3.5 Movement information

Cycle lanes	0 km (0% of street network)
Bus lanes	2.94 km (18.17% of street network)
Accessibility (pedestrian net. less than 1:20)	100%
Estimated CO_2 from daily trip generation	0 kg/year
Daily vehicle trips	585
Total parking spaces	3025
Total parking spaces required	530
Net parking spaces	2495

4.4 Decisions

Findings and the hypothesis arising from analysis shows the need for using mixed sustainability theory and practice, with integration of the technical, economic and social and design elements. New large-scale project design and construction projects must follow stringent sustainability regulations, while smaller units remain exempted and retrofitting has not yet been regulated. Moreover, the forthcoming approach of redesigning and improvement to the Dubai Sustainable City intends to describe how the surroundings urban context can work together with the Dubai Sustainable City project and be integrated in harmony with the project's urban context. The intention is to be beneficial and implement sustainability in a step-by-step way, leading to an integrated urban system.

5 Strategies

The main strategies and points approached by this study are enhancing the urban sustainability of the case study. A car free community should be introduced, after

proposing convenient and clean methods of transportation in the community. Cycling facilities should be integrated with dedicated routes and storage. Street sections should be identified on the basis of providing people with a walk able community via shaded pedestrian routes). A change in the orientation of blocks will offer better air quality and ventilation purposes and offer recreational space – a public realm – on both block and neighborhood bases to enhance the social experience and sustainability. Reducing the parking footprint and increasing green areas is also vital, as is enhancing the moveability and service hierarchy.

6 Results

6.1 Project access

The case study design is based on a gated community with one exit and entrance. According to LEED, sustainable community should not be gated as it should be well connected to the surrounding urban context.

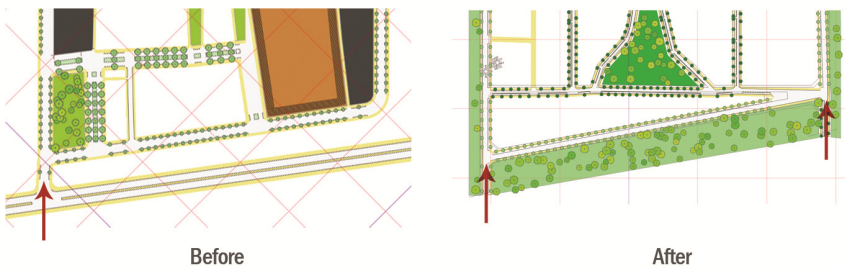

Figure 2: Case study entrances from the main road before and after redesign (source: authors).

6.2 Orientation

In order to enhance the wind flow and air quality throughout the case study, a block orientation change is proposed as a strategy allowing more airflow through

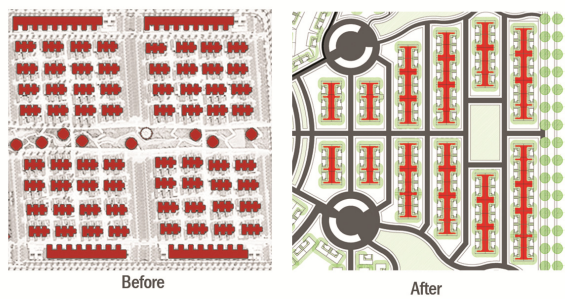

Figure 3: Block orientation before and after redesign (source: authors).

the urban tissue and enhancing the air quality. Changing the block orientation will involve it facing the favored wind direction with the long side of the block preventing the favored wind from passing through the back side of the block to being parallel to it. This will enhance the air quality and airflow through the urban tissue by channeling the wind in the desired direction.

- Flow design analysis

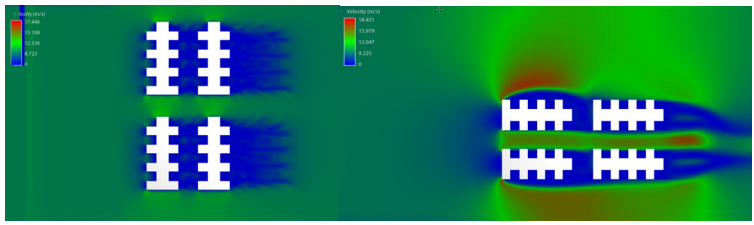

Figure 4: Air velocity simulation before and after re-orientation (authors).

6.3 Variety

The existing design of the case study only contains one type of residential unit; detached villas with two main sizes 300 sqm and 500 sqm. This gives little chance for variety and social interaction between the different classes, so a strategy aiming to enhance the performance of the urban design is that a multi-storey zone is added to the community containing a variety of apartments beside the detached and semi-detached villas. This will have the effect of providing the community with a broad line of social interaction and social sustainability.

Residential units – existing group	
Dwellings – studio flats (C3)	266 units
Dwellings – cluster flats (C3)	84 units
Semi-detached or detached housing	304 units
Total:	654 units
Total residential units (existing group)	735

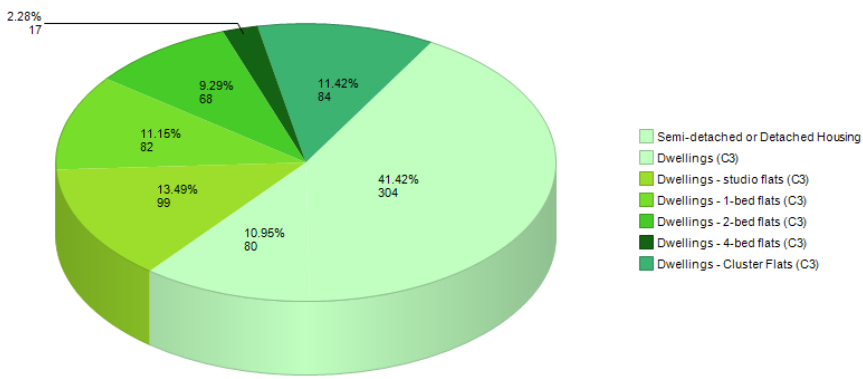

Figure 5: Residential analysis (modified design) (source: CityCAD).

6.4 Car free community

In order to achieve the goal of a livable car free community, it is essential to prevent fossil fuel cars from entering the heart of Dubai Sustainable City. Therefore, several strategies and transportation means have to be implemented.

- Centralized underground parking

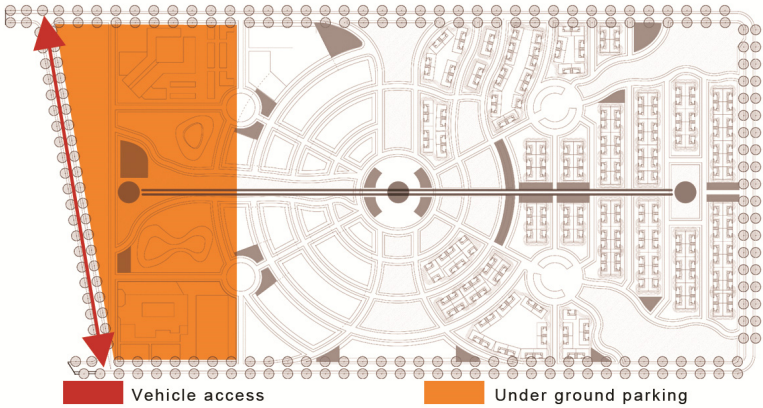

Figure 6: Underground parking and vehicle access (source: authors).

CityCAD parking analysis:

Vehicle parking:	
Total parking spaces	6723
Total parking spaces required	1447
Net parking spaces	5275
Average number of parking spaces within 5-mins walk	3879
Average number of parking spaces per residential population	2.56
Average population per entrance	46 people/entrance

6.5 Service hierarchy

Studying the case study master plan for services distribution, all services are concentrated at street elevation, providing services only to residents, as this is a gated community. All services are on one layer only, some as far as 1000 meters from some residents.

Aiming to enhance the livability of the case study as a major part of creating a sustainable community, several layers of service have to be introduced as following:

- Urban context layer: providing service to the case study as well as to nearby future urban developments in this newly developed area of the city. Examples include district cooling, school, hospital, Mosque, shopping areas, restaurants and convenience stores.

- Case study context: providing services to the community within the case study. Examples include school, community centre, sports, playgrounds, shops and gathering areas.
- Neighborhoods context: providing services for the neighborhoods such as a clinic, shop, playground and cafe).
- CityCAD livability analysis after modification:
- Average distance from dwellings to:

Green space	63 m
Health service	114 m
Education	363 m
Parking space	286 m
Shops	52 m
General/convenience store	148 m
Bank	384 m
Pharmacy	384 m
Supermarket	160 m

6.6 Moveability

Enhancing the performance of case study moveability requires the implementation of shaded walkable roads if a shading device is introduced that provides shade as well as energy and ventilation.

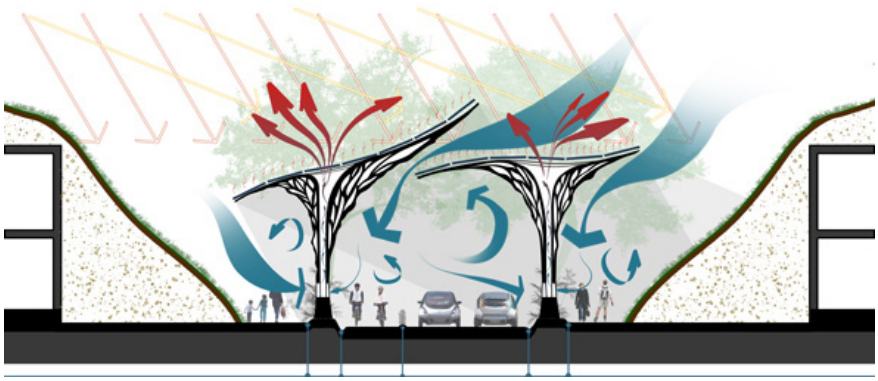

Figure 7: Streetscape and description of a new element increasing street walkability (authors).

A permeable master plan will see defined landmarks to guide people.

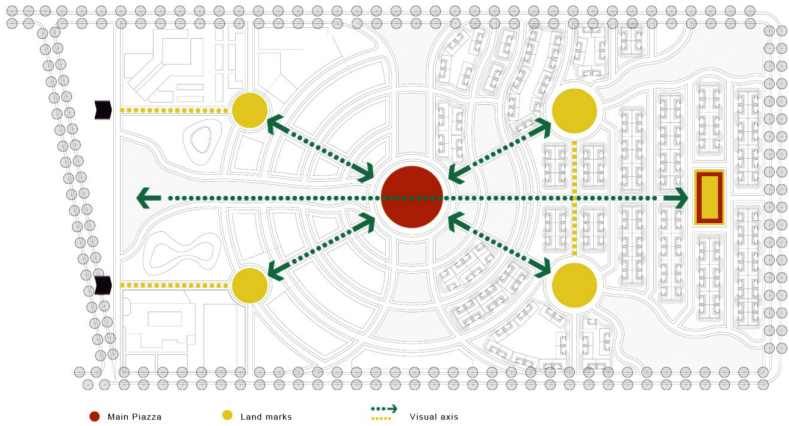

Figure 8: Main landmarks and visual axis (source: authors).

7 Conclusion

Throughout the proposed strategies observed through software analysis and simulation as well as previous reference, the design has been improved in several aspects. This is especially true in terms of the social and livability aspects, putting this project a step ahead towards building and developing a sustainable community.

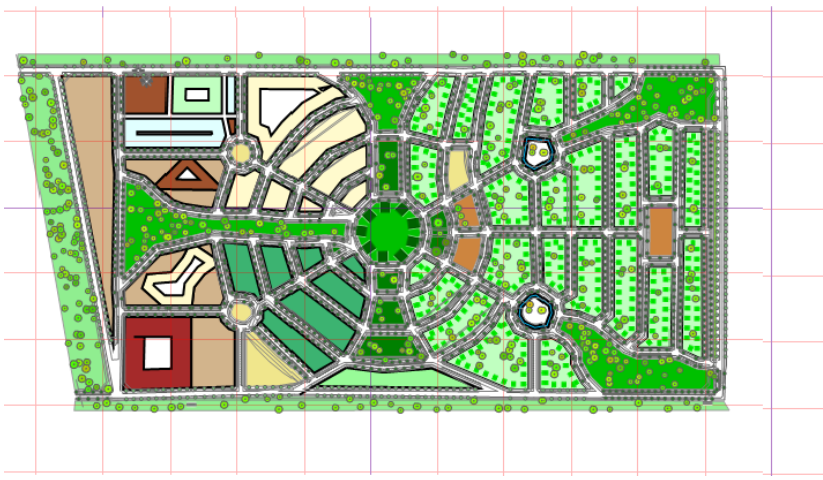

Figure 9: Master plan after applying the enhancement strategies (source: CityCAD).

Acknowledgement

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