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Emulating the desert vernacular: towards zero-carbon eco desert settlements in Egypt.

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ABSTRACT:

Zero carbon cities are relatively new concepts that aim to support cities in realizing ecological, social and economic sustainable futures. It is argued that urbanization in developing countries may be the distinct greatest challenge in this century. It is expected that 400,000 square kilometers will be built in the coming 30 years. This is equivalent to the world's built-up urban area in last 2000 years, given that cities alone account for 78 % of anthropogenic carbon emissions. Furthermore, more devastation has been caused by the latest severe climate events, such as an increased average global temperature, flooding, and massive forest fires. Accordingly, a sense of urgency has turned about the necessity to adopt sustainable and ecological design principles for future cities development. Egypt as one of the developing countries that is the third largest populated nation in Africa, is facing a series of threats. From which limited access to natural resources in relation to the population size and economic growth besides the continuous challenging climate change implications. Furthermore, Egypt is recently facing a major energy security problem, which strongly impacts all national plans for economic development. Despite that, till now there are no clear laws or legislations for eco cities like zero carbon city design and construction. The aim of this research paper is laying hands on hidden potentials and analyzing successful private initiatives for existing eco communities in Egypt. Initiatives that have tried to apply some traditional zero carbon design concepts based on lessons learned from vernacular architectural heritage in Egypt. The paper adopted an analytical case study method tackling different aspects like; renewable energy, permaculture, passive systems, green infra structure like eco-sanitation, recycling and solid waste management ending with carbon free transportation and green circular economy. The research contributes by critically analyzing such attempts and concludes with design best practices and strategies on how to reach an environmentally enriched, healthier, resilient and socially rewarding zero carbon cities, running on their own locally available resources. Hoping that the recommendations are a nucleus for a national design standard or a best practice manual towards better equitable urban future.

1. INTRODUCTION

Cities alone account for 78 % of anthropogenic carbon emissions (Stern, 2009). While in the developing world, cities actually produce and consume at higher rates than rural areas per capita (Heinberg & Lerch (eds.), 2010). Thus, accounting for an unbalanced share of greenhouse gas emissions. Moreover, most of the urban south cities with coastal locations have a high concentration of economic activity and high populations (Herring, H. (eds.), 2012). As a result, they are the most vulnerable to the effects of climate change. It is evident that cities are the core of the problem and can actually have dire consequences on human settlements both in terms of carbon

emissions and in terms of the effects of global warming. Literature suggests that low and zero carbon city design and planning can play a crucial role in reaching global targets in CO₂ reduction, ensuring long-term energy security and in reducing the impacts of climate change worldwide (Herring, H. (eds.), 2012). Therefore, there is a growing need for trans-disciplinary eco-guidelines for contemporary and future city design and planning. Vernacular heritage has shown several examples for zero carbon design and planning practice that managed to reduce embodied carbon in city planning. The question however is how can we apply such low impact vernacular concepts in our contemporary and future cities? That is the key question that this study will aim to address through

discussing three different case studies and deducing lessons for future applications

Egypt like many other developing countries is currently facing a series of threats related to the limited access to natural resources. In addition to its growing population size, economic growth, and energy poverty. All of these aspects can have a strong influence on urban development and planning. Directing future development out of the narrow Nile valley and Delta has become an indisputable necessity. Accordingly, future urban development plans for Egypt in 2050 aim at spreading development over 40% of Egypt's area (GOPP, 2013). Another key concern now in Egypt is climate change and the need to move towards a zero-carbon era. This is quite fundamental with Cairo being the most polluted capital in the Middle East. However, the majority of researchers and designers nowadays throw around the terms eco-cities and eco-economy without concise clues on how to achieve them.

Moreover, in Egypt, environmentally sustainable community initiatives have been applied on a very limited scale. There are only a few pilot settlements that aim to focus on the use of renewable energy and eco-friendly construction methods, giving them a vital edge in a nation competitive in sustainable communities. Most of these settlements however are private initiatives like Basata in Sinai, Tunis village in Fayoum, El Basaysa in Sharkeya and New Basaysa in Ras Sedr. There is only one governmental settlement so far named (PLEV) Productive Low Cost and Environmentally Friendly Village that is still in its study phase. Furthermore, in terms of rating systems and assessment tools, the Egyptian rating system 'Green Pyramid' is still on hold and has no chapters that address sustainable communities and eco-cities. Designing zero carbon eco-cities must be tackled in a more holistic approach where economic justice, behavior change, wellbeing, community self-management and the role of government and policy makers are taken into consideration. This study comes aligned with the new government decision to build a new city capital. However, the proposed design priorities self-determination without looking at affordability, low impact living and equality. Thus, there is a great demand and need for a separate code or guideline that helps in designing and assessing new or existing cities. That is what this study is trying to contribute with and fill in this gap in national codes and rating systems. This study contributes by showing broad lines for a pathway towards zero carbon city design in Egypt inspired from traditional vernacular architecture. It aims to show different design

elements from three different case studies and draw recommendations that can be used as a set of design guidelines for an eco-city model in Egypt.

2. METHODOLOGY

This study is following a qualitative approach through an investigative analytical case study methodology. First, we made a literature search for definitions that describe the eco and zero carbon city concepts. Then we tried to look at the definitions in relation to the Egyptian situation and where are we from such notions. Then we started an investigative work to select a case study that suits the purpose of the analytical phase. The focus was on desert settlements as the common city development now is in the desert land in Egypt also for the vernacular part we were looking at desert vernacular. The focus was on vernacular aspects like compactness of urban forms, high density development, mixed land use development, circulation networks, climatic and environmental considerations, building materials, housing typologies and desert architectural character. We found Basata eco-community in Sinai Peninsula in Egypt a suitable one among others. The criteria for choice was based on the sustainable eco principles and zero carbon concepts that are adopted from vernacular architecture in addition to the contribution to the local society and respect for culture and social assets. Then analytically we looked at those principles and deduced recommendation for possible future development for eco-city design and planning.

3. ECO AND ZERO CARBON CITIES

Over the last decade, both researchers and academics have been arguing around interdisciplinary concepts of eco and sustainable cities. There are many wicked and interconnected challenges like fuel poverty, climate change, and ecosystem degradation that have been intensively discussed in the discourse. Many have drawn concerns about low impact design approaches, how to make low carbon transition (Mol et al., (red), 2009) and reduce carbon footprint. Others focused on eco-urbanism while many others tackled the notions of zero-carbon and recently post-carbon. In addition to finding ways to understand new forms of carbon on calculations through carbon value change (While, 2011). Nevertheless, researchers have pinpointed that towards a road map for post-carbon cities, multiple solutions than can work on different scales should be adopted. Starting from planning fundamentals till building a sense of community and calls for mainstream policies of urban development (Jonas et al., 2011). Others highlighted the

importance of community-led approaches towards low carbon urban governance (Seyfang, 2009) and more chances for grassroots policies (Seyfang & Smith, 2007). The idea in the end is how to design a community that can become low- to no carbon from construction phases till operation and can depend mainly on renewables in producing energy. Putting into consideration other main key principles like transportation, land use, and energy consumption. It is becoming evident now that societies with less dependence on fossil fuel resources and decarbonize their energy; necessitate occupants' behavior change and value perception. In addition, more effort is needed to adapt new technological innovations for energy saving (Hopkins, 2008). All of this should not be neglected towards defining a clear roadmap for zero carbon societies.

4. DESERT VERNACULAR SETTLEMENTS AS A SUSTAINABLE MODEL

Desert vernacular architecture in Egypt has always been considered as an example of saving resources through different levels in construction, energy and material after understanding cultural, social and environmental aspects within a specific geographical and climatic context (Dabaieh, 2011). The sustainability of desert vernacular is also about managing the balance between preservation and use. Desert vernacular dwellers show multi-layers of wisdom in their use of the limited local materials, the minimum waste of such resources and an ability to be inspired by forms from nature. In addition, from an economical point of view, such local building materials are almost cost-free, as locals use wood trees and palm trees grown on their farmlands and cast mud bricks using earth from their surroundings. People build their own dwellings, so there is almost zero labor cost. The possibility of re-using the earth material is another aspect of sustainable desert vernacular. Almost no waste product is produced from desert vernacular buildings (Dabaieh, 2011).

Generally, urbanists have studied the structure and form of traditional settlements in search of solutions for various current urban problems. Literature suggests that the design principles responsible for the development and evolution of traditional settlements were actually a means for creating sustainable settlements. These old principles, which were used naturally, resulted in the shaping of sustainable organic urban fabrics through hundreds of years. Thus, dense mixed-use neighborhoods that respect the human scale have been presented as the basics of Neo-

Traditional Development (NTD) (Handy, 1991). These had certain characteristics such as; having a center and an edge, inclusion of a mixed-use center at a walking distance from where residents live. Inclusion of employment centers so that people can live and work within the development. Public spaces and civic centers designed as focal points in order to create a sense of community. In addition to generating street life, through pedestrian friendly narrow streets, wide walks, and street landscaping (Handy, 1991). Furthermore, many examples have shown the validity of vernacular architecture as a sustainable model from both its concept and relation to nature and from adaptation to the social system (Diaz, Navarro & Machiel, 2008).

5. RESULTS: BASTA ECO-LODGE AND THE VERNACULAR ECO AND ZERO-CARBON CONCEPTS

Basata is an eco-lodge for tourists' activities with a main goal of supporting the Bedouin local community located Nuweiba in South Sinai, Egypt. The eco-lodge includes main residential units and educational centers. This allows the local Bedouins to have access to basic education, which lacks in this remote part of Sinai. Basata attempts to create a special self-sustained eco-community around the main activity of tourists' units (huts and chalets) that has a relatively low impact on the surrounding environment and the native inhabitants.

5.1 Site Planning: The approach for site planning aims for satisfying living needs and to change radically to a more efficient use of land. The site planning reduces the ecological footprint with a minimal level of urban density.



Figure 1 The urban layout and the arrangements of huts and chalets in Basata showing the footprint and low density.

5.2 Architecture: The architecture, building materials and building technology in Basata is influenced with desert vernacular architecture in the surrounding region and beyond. The main materials used in Basata's residential units are natural wide-spread biodegradable materials in Egypt; like reeds, clay, straw and natural stones. The idea of mainly using reeds, baby bamboo, straw and clay is to reduce the embodied carbon in the construction and also in lifetime energy usage. The applied indigenous construction methods reflected the local vernacular architecture of the region. The design was a response to cultural and social aspects as well. The main notion is emphasizing the special character of the desert architecture and avoiding using any materials that can harm, pollute the environment or have high embodied energy together with eluding the use of any heavy construction equipment to avoid noise pollution during construction. The local Bedouin community in the area were part of the construction process to empower their abilities and help in revitalizing the traditional building crafts.



Figure 2. Sample for the hut design using bamboo reeds and local wood.

5.3 Passive Strategies: were applied for cooling, heating, ventilation and natural daylight. The optimal use of natural wind patterns from the sea and night flush effect from the desert land together with encouraging cross ventilation reduced the need for air-conditioning or any other form of artificial cooling in summer especially inside the reeds and bamboos huts. While in the Adobe/stone chalets the high thermal mass of the walls and high domed ceilings played a major role in reducing heat gains during summer and providing adequate indoor thermal comfort all year round. In winter for example, the warm night sea breeze and thermal mass of the chalets stone walls helps in providing warm indoor comfort with minimal need for night heating.



Figure 3. Sample for the passive approaches used for ventilation and daylight.

5.4 Waste Management: Waste sorting has a strict policy in Basata. Excess organic food from cooking and from left over meals is used to feed animals grazed on site. Animal manure is used as an organic natural fertilizer for the plants and it is also used in the clay soil mixture in building. All solid recyclable materials are sorted and picked by a local NGO to the solid waste transfer stations, where it's further sorted and sent for recycling main factories in Cairo. There is a water desalination plant onsite that produces fresh water and brine water (highly concentrated salt water). Also, they apply strict water conservation policy. Fresh water is used; in kitchens only for cooking and rinsing the dishes while in the bathrooms, only for showering and hand washing. Brine water is used for the rest of purposes like washing the dishes, toilets flush and for construction work. In toilets water saving taps are used and that helps in reducing water consumption. On average, each person uses from 70 to 100 liters of water per day, compared to an average of 500 liters per person per day in neighboring tourism communities. As for wastewater, it is divided into grey water and black water. Grey water is used for irrigating non-edible crops, endemic palm trees and plants. The salty black water goes into sealed septic tanks and then is transferred to the main water treatment plant.



Figure 4. Shots from the recycling station near by Basta, owned by the local NGO in partnership with Basata community.

5.5 Energy management: The project is located in an off-grid site so as an essential need; they had to start with diesel generators, as renewable energy was not feasible in terms of high cost. Now, solar panels are gradually starting to replace the generators for electricity, and solar heaters for water heating. Energy saving light bulbs are also used. In some units, there are some basic electric equipment; but no air-conditioners are installed, nor TV sets, refrigerators, or electric entertainment facilities. In wintertime, electricity generators are usually turned off for several hours during the day, since kitchen refrigerators are not in use as much. One of the strategies to reduce light pollution on site is to minimize the outdoor lighting features.

5.6 Mobility: As for mobility, it is easy to cycle or walk and move around the place even if there are no specific cycling or walking lanes. There is no artificial planting or importing non-endemic flora. Grass is not used as ground cover because it requires huge amounts of freshwater and polluting fertilizers. The main idea in Basata is to have a car-free community. The car parking spaces are only on the entrances of the project and cars are not allowed further on. Walking and biking are the main mobility mean.

6. DISCUSSION

A sustainable neighborhood design approach must begin with focusing on the relationship between transportation, urban form (streets and blocks), and mixed use (Fraker, 2013). It is essential for example in creating a high-quality pedestrian environment with convenient and close proximity to transit stops. This is essential in order to guarantee a high percentage of trips using public transport, which consequently will reduce car dependency. To encourage prompting such ideas towards eco-cities, we need to apply action plans and promote for main key concepts that can help a community to live in a sustainable, environmentally responsible way. Some like establishing a commercially viable clean business and economic model that offers to local city residents and organizations a desirable place to live and work. A sustainable eco-city starts from the design stage and should be maintained during construction and continues throughout the city's operation. A city that produces more energy than it consumes is not anymore a luxury, it is a must to cope with energy crises. In addition, our planning legislations and laws should offer

zero taxes and zero tariffs for any initiatives towards eco design and planning.

In this context, it is crucial to learn from previous experiences, and mainly from the traditional settlements that proved to respond efficiently to inhabitants needs while having a minimal negative impact on the environment. It is necessary to find a way to understand which aspects of vernacular architecture can be useful, and are still feasible, and which ones are to be improved. Naturally, all these ideas have different answers regarding the diverse cultures, economic systems and development levels in each place. But it is also clear that there is a tendency towards balancing the development levels: the industrialization process of all countries seems to be a continuous operation, although the stages reached have not been the same. The design of the city could still be inspired by traditional and vernacular architecture and urban planning of the region and be more culture responsive to the spirit of our rooted Egyptian tradition. We have numerous examples of our traditional design techniques that proved along centuries that it helped in reducing energy consumption and improved the quality of the environment.

7. CONCLUSION

This study attempted to look at essential principles for eco and zero carbon practices for cities using Basata eco community as a case. We tried to drive some basic applications that could give some clues on better applications for our future design and planning. This study should be followed by more extensive research on designing more concrete recommendations to be used as a design guidance. Vernacular architecture still offers evidences on zero impact living.

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