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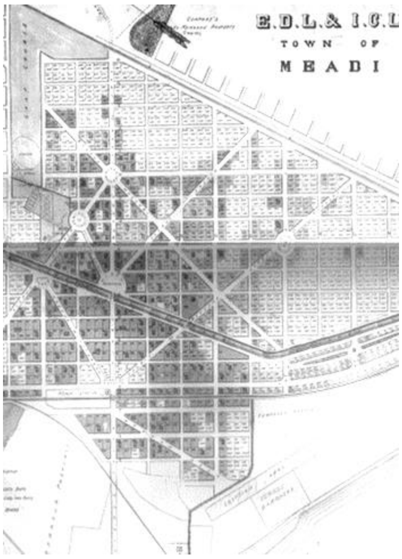

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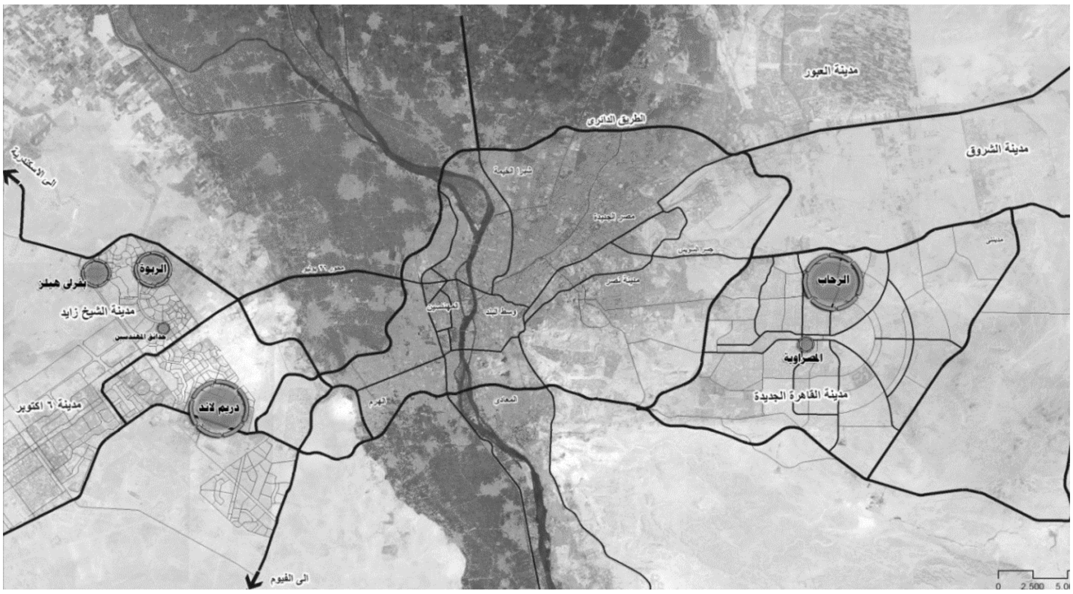

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Energy Performance Benchmarking Methodology for Palestinian School Buildings in Gaza strip

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ABSTRACT:

In Palestine, nine hundred classrooms are needed to be built every year to cope with the increase in population. Many schools were obligated to work on the double shift basis to solve the problem. The Ministry of Education (MOE), the United Nations Relief and Works Agency for Palestine Refugees (UNRWA), and Private Sector are the three entities that provide educational facilities in Palestine. In most cases, the school building designs are standard prototypes that are not site-specific or climate-based. This resulted in thermal discomfort in educational spaces that lead many schools to install HVAC systems to maintain indoor comfort.

School building designs are required to be more efficient climate-based and energy-conscious while maintaining indoor comfort levels. Despite the presence of a Palestinian energy-efficiency building code since 2004, no energy benchmarks for buildings were specified. In order to develop energy-efficient school building designs in Gaza strip, an energy benchmark is needed to assess new designs. This study aims to develop an energy building dataset methodology in order to benchmark energy performance of Palestinian school buildings at an early stage of the design.

The benchmarking methodology was based on field survey and simulation methods. Based on the survey, two school buildings representative of schools developed by MOE and UNRWA were selected and were used as reference buildings. Both were simulated for energy performance, delivering energy use intensity (EUI) for heating, cooling, and lighting. A virtual building database was created to test alternatives of building envelope parameters, classroom occupancy density and building orientation. An optimized best practice building was developed. Its EUI value was used as target values. The savings compared to reference buildings of MOE and UNRWA reached 28% and 35% respectively.

***Keywords**: Energy Performance, Building Envelope, School Buildings, Benchmark*

منهجية تحديد مؤشر أداء الطاقة بالمباني المدرسية في قطاع غزة بفلسطين

الملخص:

تهدف هذه الدراسة إلى وضع منهجية لبناء قاعدة بيانات خاصة بتقييم أداء الطاقة للمباني المدرسية المكيفة في قطاع غزة في مرحلة التصميم. يتولى الاشراف على التعليم في مناطق السلطة ثلاث مؤسسات تعليمية هي وزارة التربية والتعليم والاونروا والقطاع الخاص

تحتاج المناطق الفلسطينية إلى توفير 900 فصل دراسي سنوياً نتيجة التزايد المستمر في أعداد الطلبة، مما نتج عنه زيادة عدد الطلبة داخل الفصل الدراسي. وقد قامت وزارة التربية والتعليم بوضع استراتيجيات لتحقيق الاستدامة لتحقيق

الراحة داخل الفراغات التعليمية، ولكن ما زالت تعاني هذه المباني من عدم تحقيق الراحة الحرارية داخلها في الفترات التعليمية التي يقضي بها الطالب أطول فترة، مع تزايد الطلب على نظم التكييف الميكانيكية مع التأكيد على الحاجة الماسة لتقليل الطلب على الطاقة.

يمثل جمع البيانات عن المباني المدرسية المكيفة في فلسطين مشكلة كبيرة حيث لا توجد بيانات كافية عن كمية الاستهلاك أو مرجعيات يمكن الاسترشاد من خلالها. لذا كانت الحاجة لتكوين قاعدة بيانات أو قيم مرجعية لتحديد مؤشر لأداء الطاقة في المباني المدرسية في فلسطين، وقد حددت الدراسة عناصر غلاف المبنى كأحد أهم عوامل قياس الطاقة وذلك بالاستعانة بأسلوب المحاكاة والدراسة الميدانية في جمع المعلومات والبيانات عن المباني المدرسية في غزة.

قامت الدراسة بدايةً باستعراض الحالة الراهنة للمباني المدرسية في فلسطين والجهود المبذولة للتصميم المستدام ونظم تقييم الطاقة وذلك لبلورة الأفكار حول كيفية تحسين الأداء، من ثم طورت الدراسة نموذج محاكاة افتراضي يحدد خصائص غلاف المبنى إضافة إلى المتغيرات المختلفة لإشغال المبنى والتوجيه، وتستند عملية القياس في هذه الدراسة على البيانات الفعلية والمعلومات التفصيلية للمباني من خلال الدراسة الحقلية. وقد توصلت الدراسة إلى وجود نموذجين محددين للمباني أحدهما تابع لوزارة التربية والتعلية **MOE** بقيمة استهلاك 191ك.و/م2 وآخر تابع **UNRWA** بقيمة 211 ك.و/م2. هذا ويمكن إجراء تحسينات على أداء غلاف المبنى للوصول إلى أقل معدل استهلاك للطاقة، من خلال تقنين أداء الطاقة تم التوصل إلى أفضل أداء للطاقة بقيمة 137 ك.و/م2.

INTRODUCTION

There are three types of authorities providing education to the Palestinian students: the government – through the ministry of education (MOE), the United Nations Relief and Works Agency for Palestine Refugees (UNRWA), and Private Sector [1]. Palestinian school buildings (PSB) in Gaza followed two standard designs applied by MOE and UNRWA. Using standard designs minimized the construction period and minimized cost [2]. However, in terms of sustainability and energy-efficiency, the performance of these prototype designs becomes questionable. Although strategies have been developed to achieve thermal comfort in the educational spaces such as classrooms, these buildings still suffer from thermal discomfort at periods of learning. The growing demand for air-conditioning systems that help achieve comfort levels creates a challenge against the urgent need to reduce energy consumption in school buildings.

In order to investigate the potential of achieving energy-efficient school buildings adapted for the climate of Gaza strip, there is a need for reference building values to be used as a benchmark for comparison. In Palestine, there are no sufficient database or target values for energy consumption that can be used as an index for energy performance. [3]

This study aimed at developing a benchmark of energy performance of air-conditioned school buildings located in Gaza strip. The energy-saving potential can be estimated by comparing the energy performance indicator(s) (EPI) or energy use intensity (EUI) of a specific building with reference and target values of a building with the same function or with a best-practice building [4].

Filippin (2000), calculated the EUI for school buildings in central Argentina. The energy efficiency and emissions of greenhouse gases for 15 public school buildings were compared [5].

Hernandez et al. (**2008)** developed detailed questionnaires that were distributed to 350 schools in Ireland in order to collect detail on building construction, activities and energy uses in each building. The comparison benchmarks for the annual energy use heating were for reference buildings stock and reference regulation buildings that have been proposed by The European Committee for Standardization (CEN) [6].

Nikolau, T. G. (2010) developed a dynamic simulation model for generalization and creation of virtual building dataset (VBD) of random office buildings located in different climatic zones in Greece, taking into account the constructional and operational characteristics of the buildings and Greek legislation. The simulation outputs were EUI values of the annual energy demand for heating, cooling, electric lighting and office equipment in addition to indoor thermal comfort [4].

Radhi et al. (2008) developed a database and benchmarking software based on on-site surveys and detailed audit information. The database represented an archive for energy use in buildings and provided a comparative model. The considered operational variables included climate, building type, floor area, occupancy and equipment. The software performed two functions: assessment of energy-efficiency of buildings compared to similar buildings nationwide; and setting a realistic and achievable energy target of a medium sized office building in Bahrain that was benchmarked using a database and benchmarking software and compared the outcome with that from a recent benchmarking field study [7].

The most common method for creating a database is through the collection of building data in audits. Despite this, the creation of representative building data sets based on the application of building simulations for a range of energy parameters (virtual data set) could constitute a reliable and time-saving substitute for the real building data collection [4].

Literature showed that in addition to building energy audits, using energy performance simulation tools is beneficial in the benchmarking process to help model and assess new and existing buildings using alternatives of construction materials and building parameters, in order to specify target reference values.

This study aims at developing a suitable methodology that helps provide a benchmark for energy performance of an air-conditioned school building located in the Gaza strip.

1 LIMITATIONS

This research is limited to the parameters of external walls of the building envelope, classroom occupancy density and building orientation.

2 RESEARCH METHODOLOGY:

The benchmarking methodology as illustrated at figure (1), was based on field survey and simulation methods. Based on the survey, two school buildings representative of schools developed by MOE and UNRWA were selected and were used as reference buildings. Both were simulated for energy performance, delivering energy use intensity (EUI) for heating, cooling, and lighting. A virtual building database was created to test alternatives of building envelope parameters, classroom occupancy density and building orientation.

The methodology adopted in the study for collecting data and setting the database can be summarized in the following steps:

1. In order to figure out the current situation of Palestinian school buildings (PSB) in terms of performance, a literature review of the educational system, building design and local energy code was conducted, and the local climate was analyzed.

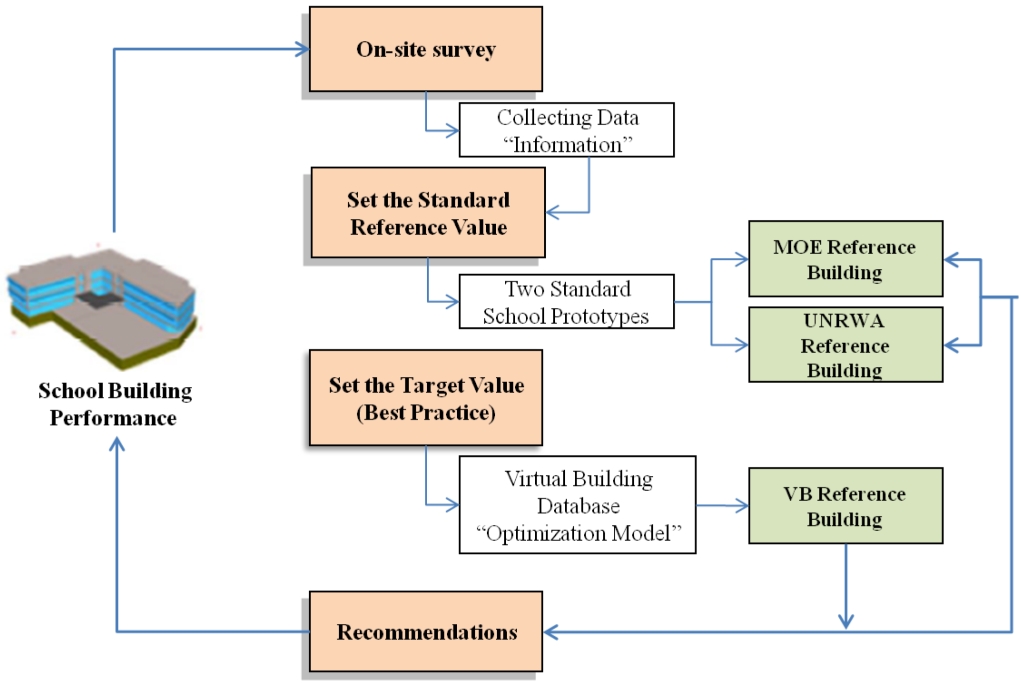
2. An on-site survey of school buildings located in Gaza was performed to detect the commonly used construction materials. A detailed survey template was designed for a number of local existing school buildings in Gaza. The surveyed school buildings included the school prototypes developed by both of the MOE authority and UNRWA.

3. The school prototypes developed by both MOE and UNRWA were modeled in *Designbuilder* software. The commonly used construction materials deduced from the on-site survey were implemented in the models. Both models were simulated for annual energy performance using the *EnegyPlus* software as the simulation engine. The resulting annual EUI values for both prototypes were set as reference values of the existing school buildings and were used for comparison.

4. As the building envelope is a key contributor in a building's energy performance, a third virtual model was developed and used as a Virtual Building Database (VBD) in which alternatives of building envelope parameters were tested for their impact on the overall annual EUI. The tested parameters included the construction materials of opaque and transparent parts of the envelope as well as alternatives of the window-to-wall ratios.

5. Based on the results of testing alternatives of each component of the building envelope, an optimized model was developed using selected alternatives that proved to minimize the consumed energy. The EUI results of the optimized model showed a best practice building. These values were compared to the EUI values of the two reference buildings developed by the MOE and UNRWA in order to investigate the potential energy savings.

Figure (1) The research methodology steps framework



3 Background of Palestinian schools (PSB):

The West Bank and Gaza Strip -usually called the Palestinian Territories (PT)- are located at latitude 31°N. Gaza Strip region (365km^2) which is a coastal area in the west-southern part of Palestine at geographical coordinates (31°N, 34°E). It forms a transitional zone between the sub-humid coastal zone of Palestine in the north, the semiarid plains of the northern Negev Desert in the east and the arid Sinai Desert of Egypt in the south [8].

3.1. Energy situation:

The residential and commercial sectors in the PT account for about 60% of its electricity consumption, most of which is used for heating, cooling and lighting in buildings. The PT remained largely dependent on energy imports from Israel [9].

There are three providers of electric energy that supply Gaza with electricity. The first is the Israeli electricity company, which supplies 120 MW. The second is the power station of Gaza and its theoretical capacity is to produce 140 MW, however, it usually produces one third of this capacity. The third one is the Egyptian electricity grid that supplies Rafah city in Gaza Strip with around 27 MW. However, the supplied electricity does not fulfill the demand. This results in frequent power outages and in the need to use fuel generators for the most essential facilities [10].

Figure (2) Map of Palestinian Territories and Gaza Strip

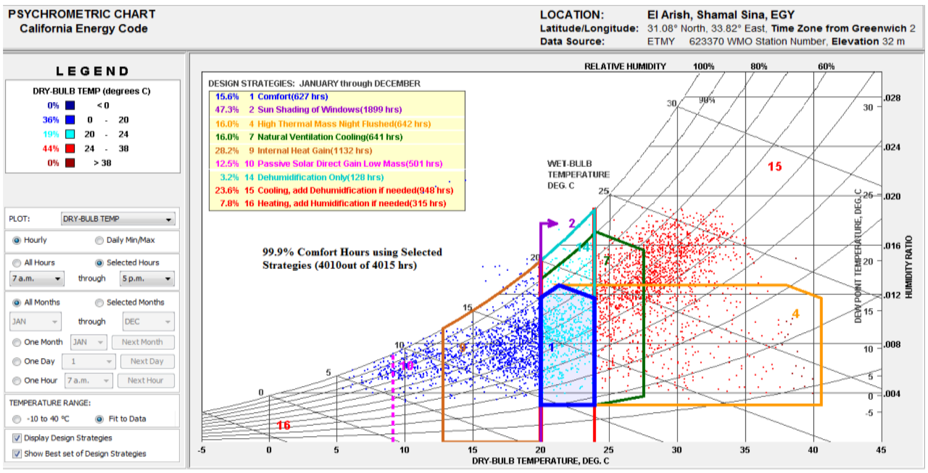
Source: http://en.wikipedia.org/wiki/Gaza_Strip

3.2. Climate analysis:

The average mean temperature for Gaza ranges from 25^{0}C in summer to 13^{0}C in winter. Daily relative humidity fluctuates between 65% in the daytime and 85% at night in the summer, and between 60 % and 80 % in winter [8]. It has a relatively high solar radiation approximately 2861 annual sunshine -hour sunshine throughout the year with average daily solar radiation on a horizontal surface is about 222W/m^2 [9].

There was no available weather data file for Gaza sector. This study used the weather data of the nearest city which was Al-Arish city in Egypt. The psychometric chart during the schools' occupancy period (from 7:00 am to 5:00 pm), (Figure 2), showed that the period that lie out of comfort zone was 80% annually. The temperature was higher than the comfort zone in 44% the occupied period while it was lower than the comfort levels in 36%. This indicated that the building envelope design and composition should be thoroughly considered to mitigate the effect of external climatic conditions.

Figure (3) Psychometric chart of Al-Arish weather data



Source: [18]

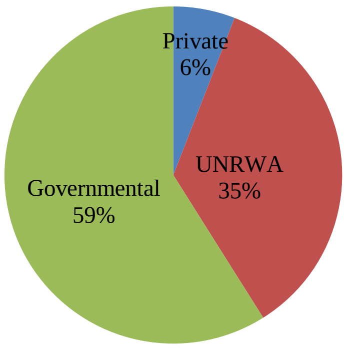
3.3. School Buildings in Palestine:

Palestine has a high natural growth rate with an annual increase of about 4.5% [11]. Because of that, the Palestinian government continued to increase the number of schools by building about 900 new classrooms every year in order to cope with this annual natural increase [12].

3.3.1. Structure of Educational System:

The total number of schools in 2012/2013 was 2,753. Of them, 74% were located in the West Bank and 26 % in the Gaza Strip. In Gaza Strip, more than 460,000 children attend 688 elementary and secondary schools. Of them, 396 schools were developed by the government (59%), 244 by UNRWA (35%) and 48 ones by the private sector (6%). These schools were designed according to the standards manual developed in cooperation with UNESCO [1]. The traditional "standard school designs" were ("I", "L", "A" or "U" shaped buildings that were not site-specific) [14].

Figure (4) Structure of the Educational System of PSB at Gaza



Source: Palestinian Central Bureau of Statistics, March 2014.

Double shifts and class occupancy density: Due to the increasing number of students, many schools have been forced to operate on double and triple shifts, leading to reduced learning time. It is estimated that an additional 260 schools (160 schools for the MOE and 100 for UNRWA) are needed to accommodate new students and to reduce the pressure on schools operating on a double and triple shifts [15]. The overall number of schools operating on a double shift system was reduced from 86% in 2012 to 71% in 2013 and the class occupancy density was maintained at 38 students per classroom, down from 49 students per classroom in 2000, in spite of the population increase [17]. The occupancy density in elementary schools was higher in Gaza (42 students per classroom) than in the West Bank (31 students per classroom). The local standards specify 36 students per classroom as a recommended number [14].

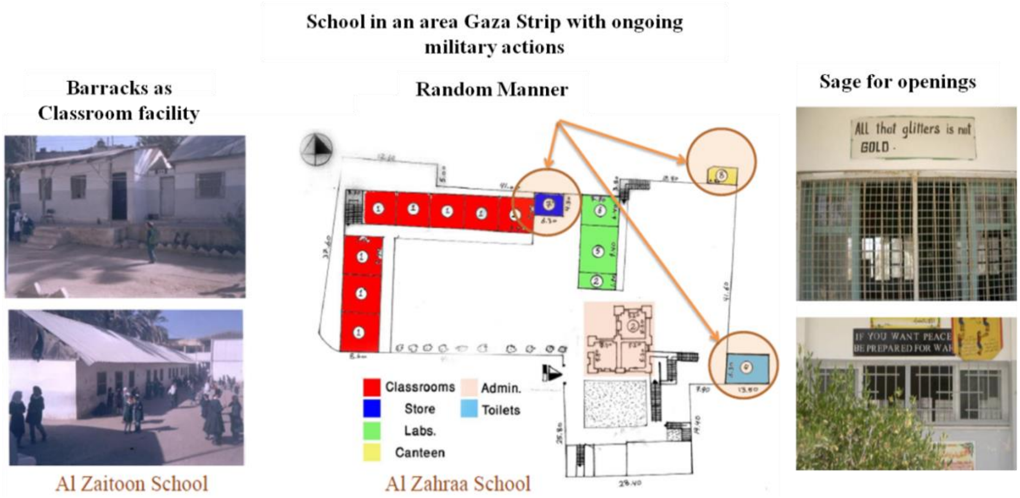
3.3.2. School Building development in Palestine

The development of schools in Palestine passed through several phases:

1. **Pre 1994 Phase:** Schools were built randomly to accommodate the continuous increase in the number of students without considering the provision

of basic amenities such as laboratories, playgrounds, computer labs and other facilities. Environmental considerations were, in general, not accounted [16].

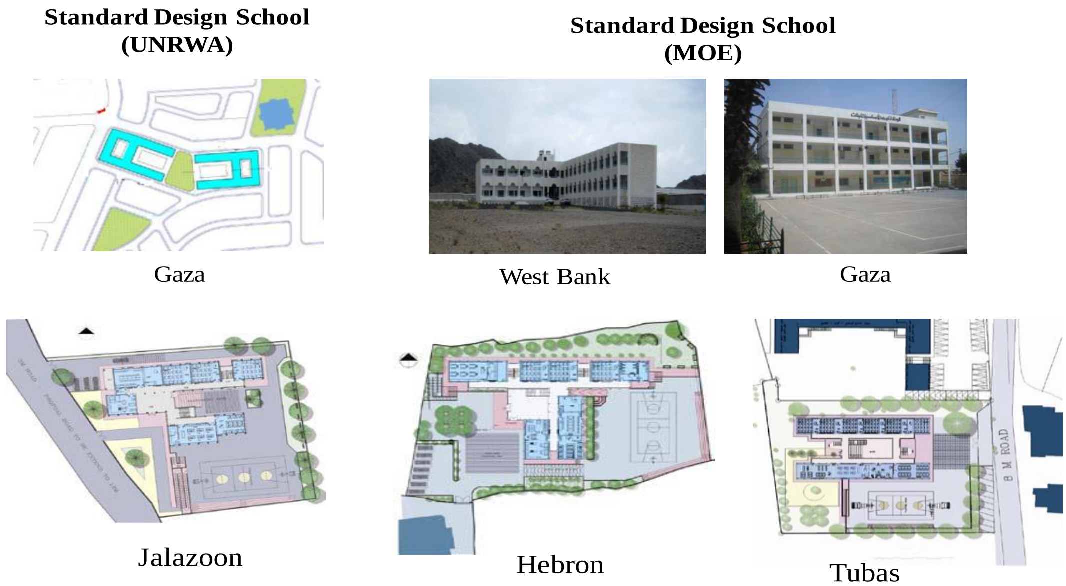
Figure (5) Random design for school facilities (Gaza)



Source: [16]

2. **Phase of the Palestinian Authority**: the authority moved towards supporting institutions and associations to help provide and improve education for Palestinian students. That created many of the school buildings funded by donors such as KfW (German government-owned development bank), EIB (European Investment Bank) and USAID (U.S. Agency for International Development). Such donors helped the MOE launch projects that showed changes and development in school design to consider the surrounding environment (colors, materials, landscaping etc.) [2]. School designs and construction drawings were provided from the donor's side.

Figure (6) Examples ofschooll building at different citiesint Palestine



Source: [2] and [14]

3. **Since 2008,** MOE and UNRWA have been engaged in the implementation of pilot projects to create environmentally friendly school facilities “eco-schools”, with the aim of reducing the burden on the environment, contributing to environmental education, promoting for the development of this type of schools. As a result of these efforts, Palestine, now is trying to design and build numerous eco-school model projects [12].

The need for new schools, extensions and rehabilitations in the West Bank and Gaza is still immense. Although many schools started to make a decisive move towards sustainable development, the existing schools in Palestine need to be more sustainable. There is little indication that these efforts have succeeded in changing overall design practices in Palestine towards improved energy efficiency.

4 Local School building’s Energy performance:

For almost 30 years, countries as the UK have been producing energy benchmarks and performance guides. For example, the Good Practice Guide 343 considered that typical and best practice values for primary schools are **157**kWh/m^2/year and **110**kWh/m^2/year respectively. In the code of practice on Energy Efficiency and Use of Renewable Energy for Non-residential Buildings, it is suggested that the target EUI for office buildings is **the 136kWh / year**/m^2 [6]. In Palestine, there is still a need to establish benchmarks to enable comparison of a particular building’s energy performance.

4.1. The Energy Efficient Building Code for Palestine:

In 2004, the project of the development of an Energy Efficiency Building Code (EEBC) for PT was completed. It focused on the climate of Palestine region for West Bank and Gaza [17]

The goal of this code was to promote energy conservation in buildings via the appropriate thermal design of envelope building elements, and to promote environment protection by reducing the greenhouse gas emissions from heating and cooling of buildings. It was expected to guarantee thermal comfort and healthy indoor environment, which would increase productivity [3].

The code contents included basic principles of thermal design, thermal storage and its role in construction elements, and the use of thermal insulation. It included thermal properties of construction materials [17]. It did not specify energy benchmarks for any building type. The code is not mandatory and not extensively adopted. This study used the code as guidance for material thermal properties.

4.2. Setting Benchmark for Palestinian Schools Application:

The process of setting the benchmark included the on-site survey, modeling and simulation of two reference buildings in addition to modeling and simulation of the virtual building database.

4.2.1. On-site survey:

The process of data collection was applied through on-site questionnaires and surveys from building facility managers and school design drawings of 10 schools in Gaza strip. The selection of schools was based on both their size and date of construction. Average-sized schools that included 28 to 33 classrooms were selected. Schools constructed date starting from the 2000 was eligible for selection to represent the second phase of school development in PT.

The collected information for school buildings included:

- Building envelope description
- Operational data: HVAC system, school schedule and occupancy density.
- Annual energy consumption of electricity recorded from the energy bill.

Table 1 shows the survey results of existing building characteristics. In local school buildings, the hollow cement block was commonly used for walls. Single glazed windows were the common case, School occupancy densities were high. It ranged from 40 students per classroom for low-basic level schools and 36 for high-basic level. This high density forced the school schedule to be worked on a double shift basis. The main energy use was consumed by artificial lighting as HVAC uses for laboratory spaces only. The surveyed schools included prototypes developed by both MOE and UNRWA.

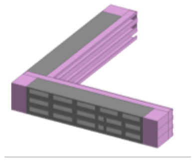
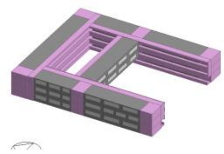
Table (1) Existing building characteristic

Element	U- value (W/m^2-K)
Roof	1.93
External Wall	1.23
Floor	2.1
Glazing type	5.7
Schedule	Double shift From7:00am-4:45pm
Activity	Basic learning school

4.2.2. The Standard Reference Building:

The MOE and UNRWA school building prototypes were modeled and simulated for energy performance using the common construction materials were derived from the survey. Table 2 shows the tested schools' design and simulation parameters. Annual and monthly energy consumption for heating, cooling and artificial lighting was the derivatives. For the current growing need to condition, educational spaces, both school buildings were assumed to be air-conditioned.

Table (2) Input data of existing reference building

Building construction material:				**School A: MOE**	**School B: UNRWA**
U-value (W/m^2.K)	**External Walls**	2.74	20cm Single hollow block cement	Total area = 1720 m^2 Occupancy= 0.625student/m^2 	Total area = 1245.5m^2 Occupancy = 0.75 student/m^2 
	Glazing	5.7	Single glazed 6mm: **VLT:** 0.88%, **U-value:** 6.12 W/m2.K**, SHGC:** 0.81		
	Roof	0.642	Hollow block reinforced concrete slab Insulated with 7cm concrete foam covered with single ply plastic bitumen 4mm		
Internal Lighting gain: (W/m^2) = 4.5					

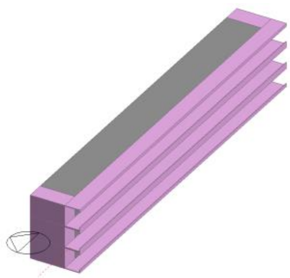
Simulation results showed that the total EUI_{MOE} = **191** kWh/m^2, of which 96% were used for cooling and only 4% for lighting, while heating energy consumption was negligible. On the other hand, the EUI_{UNRWA}= **211**kWh/m^2 of which 93% for cooling and 7% for lighting. It was clear through monthly results that energy for cooling increased in the period from April to October. It was observed that internal heat gain from occupancy was larger than heat gains from external loads by about 9%. This result indicated that the occupancy is a main parameter that had to be considered.

4.2.3. Virtual Building Database and Best-Practice:

Virtual Building Database (VBD) was developed in order to assess the effect of alternatives of building envelope components and occupancy alternatives on energy performance. On this model different envelope parameter were investigated by testing the different alternatives of building envelope components, Table 3. This included external wall U-value, thermal insulation thickness, window-to-wall ratio (WWR) and the type of glazing. Different classroom occupancy densities were also investigated. The building model was tested in the four cardinal orientations. Internal loads from occupancy and artificial lighting only were accounted for.

First, alternatives of each single parameter were tested, and then based on the results; the optimum performing alternatives of all tested parameters were combined, applied on the model and simulated. This represented the suggested optimized best practice case. The detailed results of the whole experiment including all tested parameters are discussed in a separate research. The results of the best practice case are shown in this research**.**

Figure (7) The base case design for Virtual Reference Building



Area : 304.7 m^2
WWR: 25%
Flat roof 0.52 W/m^2.K
External walls 2.70 W/m^2.K
Windows 6.12 W/m^2.K
Lighting 300 Lux
Occupancy 0.8 students/m2
Split & mech. Ventilation

The base case model

Table (3) investigated variables for the base case

<table>
<tr><th>Parameter</th><th colspan="4">Range of values</th></tr>
<tr><td>Building orientation</td><td colspan="4">N, E, S, and W</td></tr>
<tr><td>Occupancy</td><td colspan="4">0, 0.4, 0.6, 0.8, 1.0, and 1.2 student/m2.</td></tr>
<tr><td rowspan="5">External walls</td><td colspan="3"><u>Wall type</u></td><td><u>U-value</u></td></tr>
<tr><td colspan="3">Hollow cement block,</td><td>0.77</td></tr>
<tr><td colspan="3">Solid Concrete block,</td><td>1.67</td></tr>
<tr><td colspan="3">Hollow cement block with an outer limestone layer 5cm,</td><td>2.18</td></tr>
<tr><td colspan="3">Cavity wall with an outer limestone layer 5cm</td><td>1.7</td></tr>
<tr><td>Insulation</td><td colspan="4">Hollow cement block with 3,5,7 cm of insulation layer</td></tr>
<tr><td>Window-to-wall ratios “WWR”</td><td colspan="4">15%, 20%, 25%, 30% and 35%, the ratio of glazed area to both inside and outside facing wall.</td></tr>
<tr><td rowspan="7">Glazing type</td><td>Glazing type</td><td>Visible light (VL) Trans.</td><td>SHGC</td><td>U-value</td></tr>
<tr><td>Single clear 6mm</td><td>0.88</td><td>0.81</td><td>6.12</td></tr>
<tr><td>Single green 6mm</td><td>0.75</td><td>0.59</td><td>5.70</td></tr>
<tr><td>Double green (6mm-13mm air space)</td><td>0.66</td><td>0.49</td><td>2.71</td></tr>
<tr><td>Double clear LoE e2=1 (6mm-6mm air space)</td><td>0.75</td><td>0.56</td><td>2.44</td></tr>
<tr><td>Double clear LoE e2=1 (6mm-13mm air space)</td><td>0.75</td><td>0.56</td><td>1.78</td></tr>
<tr><td>Double clear LoE e2=1 (6mm-13mm argon)</td><td>0.74</td><td>0.56</td><td>1.50</td></tr>
</table>

The optimized best practice model parameters included external walls of hollow cement block (U-value 0.77), no thermal insulation, window-to-wall ratio 25%, double glazed green tinted glass in windows and occupancy of 30 student/classroom (0.6 student/$m^{2)}$.

The simulation results of the best practice school building are presented in figure (7). Results showed that the south-oriented building was the highest in consumption, followed by the east and west-oriented classrooms. The north-oriented classroom case was the lowest in consumption that reached a total EUI of only 137kwhr/m^2. This value represents the achievement of 28.2% savings when compared to the MOE reference school building and 35% savings when compared the UNRWA reference school building.

Despite being the highest in energy consumption, the south-oriented case achieved significant savings reaching about 10% and 18% when compared to the EUI of the MOE and UNRWA reference buildings respectively.

These results indicated that large energy savings were achieved by making an optimized combination of construction materials and design of the building envelope joint with adjusted occupancy density and appropriate orientation.

Figure (8) total energy use for the three reference values for school building located in Gaza, Palestine
"MOE reference building, UNRWA reference building and Virtual reference building"

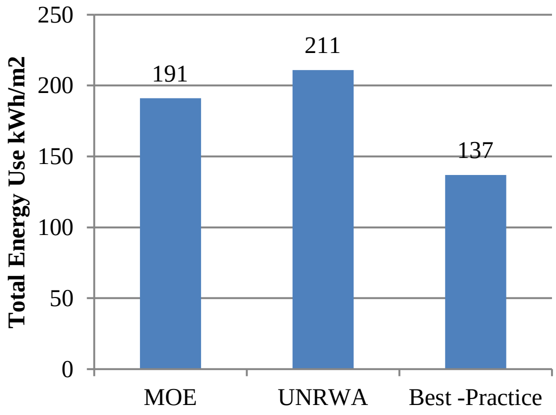
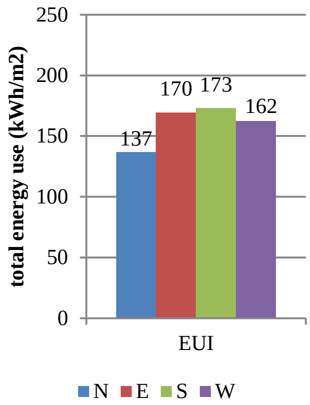


Figure (9) –the base case annual heating, cooling and lighting Loads, at WWR 25% and 0.6 occupancy



5 CONCLUSION

There is an increased demand on air-conditioning Palestinian school buildings in order to maintain comfort. In the meantime, there is a lack of energy resources and an increased demand for energy-efficiency in school building design. The energy School building envelope characteristics determine a large part of energy used in a school building

The two main studied prototypes represented the most common standard applied cases for school buildings developed by both MOE and UNRWA. Both prototypes were considered as standard reference buildings, modeled and simulated for energy performance using the common construction materials. Annual EUI values for MOE and UNRWA prototypes were 191 and 211KWh/m^2 respectively, and they were considered as standard reference values. They were far higher than international target values. The energy performance of the simulated buildings was, thus, not efficient. Internal loads from occupancy were 9% more than external loads from the envelope and indicated that specifying occupancy density is crucial.
VBD can help the designer figure out, at the early design stages, what the most energy-efficient alternatives of building envelope design and construction materials are by offering an experimental platform that enables quantitative comparison between alternatives of building parameters. A VBD was modeled and used to make an extensive testing of different alternatives of building parameters under the local climate. It enabled prediction of energy performance for a large number of variables. Best values for each building component were combined in an optimized model.

Based on VBD simulation results, the recommended building parameters for school buildings in Gaza include: external walls of hollow cement block (U-value 0.77) with no thermal insulation, window to wall ratio (WWR) 25%, double glazed green tinted glass in windows and occupancy density limited to 30 student/classroom. The building should be north-oriented.

The north-oriented building optimized model resulted in annual EUI 137kWh/m^2 which was quite close to international standards. This value represents a best practice case and a target value that can be used to benchmark air-conditioned schools in the local climate of Gaza according to the tested parameters.

The methodology applied in this research can be extended to other building parameters, adapted to the other types of buildings and other climate data of other Palestinian cities.

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Sustainable Urban Public Landscapes:

A Study of Water as a Sensitive Landscape Element in Design Of Cairo Public Landscapes

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Abstract

Urban public landscapes are an area of land or body of water to which the public has physical and/or visual access. Its importance has been known for centuries, lately, more comprehensive knowledge has become available on the wide range of benefits they provide. Good quality public landscapes contribute to individual wellbeing, and through their social, economic and environmental values. It has been settled in Egyptian minds for several years that Egypt is not facing a water problem since we are blessed with the Nile that is providing us with our needs and even more. Based upon these settled ideas, the careless usage of water is not a case that was thoroughly studied. In the past few years, few studies and research tackled the idea that we are facing the problem of scarcity of water. According to governmental meetings and conferences, the problem of waters scarcity is getting bigger and constructive interventions and initiatives are crucially needed. Apart from the normal uses of water, irrigation is considered a large aspect that is consuming very large amount of water without much of notice. Very limited attention is given to the reuse, recycle of water. There are even deeper concepts that are barely discussed which are: water consumption of plants, definition of hydro-zones, the aesthetics of limited water usage landscapes and control systems applied to the irrigation methods providing the efficient consumption of water. The aim of this research is to, examining the efficiency of water as a sensitive element in the landscape design process in general and come up with some guidelines for sustaining the future public landscapes in Cairo.

Key words: Landscape Design, Sustainability, Irrigation, water management.

تصميم وتنسيق الفراغات والحدائق العامة المستدامة:
دراسة المياه كعنصر أساسي في تصميم وتنسيق الفراغات والحدائق العامة للقاهرة

ملخص البحث

ان الفراغات العامة بالمدن المقصود بها هي أي استعمال أو جسم مائي داخل المدن يمكن للمواطن رؤيته والوصول والدخول اليه واستخدامه. تلعب هذه الفراغات دور مهما في حياة المدن لما لها من اثار بيئية واقتصادية واجتماعية مميزة. ان الموروث العام في مصر يؤكد على انه لا توجد مشكلة في وفرة المياه نتيجة لوجود نهر النيل مما ترتب عليه عدم

دراسة الاستدامة لعنصر المياه في اعمال تصميم وتنسيق الفراغات العامة. الا انه في الآونة الأخيرة ظهر بشدة الاحتياج الى دراسة سبل التعامل مع إمكانية حدوث ندرة في توفر هذه المياه على المستوى العالمي وظهر الاحتياج الشديد لهذه الدراسة على المستوى المحلي.
يهدف هذا البحث الى تقييم كفاءة استخدام المياه كعنصر مستدام في الفراغات العامة داخل القاهرة عن طريق عرض دراسة تحليلية لحالة خمس حدائق عامة بالإضافة لشارع متميز من اجل الوصول الى مجموعة من الارشادات العامة التي تساعد على كفاءة واستدامة استخدام المياه في تصميم وتنسيق الحدائق والفراغات العامة في القاهرة.

1 Introduction

Public landscapes most commonly refers to all land and spaces that are accessible to the public, indoors or outdoors. Landscape architecture is the art and science of creating and conserving outdoor environments with respect to cultural values and ecological sustainability (Loures et al, 2007). Its major components are nonliving and living materials for design and planning, that's why the result is always dynamic and changing. Until recently, urban design was associated mainly with architecture and urban planning, and the role of landscape architecture was neglected. Landscape architects have been criticized for their urban design practices with low density, little formal sensibility, and too much open space, which at the end look like suburban environments (Tilley, 2002). Today, on the contrary, urban landscape is considered crucial to creating sustainable urban environments. Urban parks and green spaces provide numerous direct and indirect contributions to people's prosperity, wellbeing, social relations, and daily life experience. Urban landscapes are of a strategic importance for the quality of life of our increasingly urbanized society and provide significant ecosystem services, as environmentally, aesthetically, recreationally, psychologically and economically (Wong, 2012). In addition, a landscape is shaped by both natural and cultural dynamics, which also influence human life styles. Therefore an urban landscape is not only about green spaces within an urban environment. Streets and squares, playgrounds, railway and canal corridors, cemeteries, bicycle and pedestrian paths, and waterfronts are the major components of the public spaces, which provide the city with its urban landscape character (Loures et al, 2007). From a human perspective, many of the earth's landscapes are being used more intensely than ever before in the history of earth, and landscapes are increasingly being used simultaneously for several purposes (Antrop, 2005). During the post-war period, intensified land use has been furthered primarily by spatial segregation of functions. Growing land pressure and environmental problems have made this strategy problematic and a paradigm of complete multifunctional is emerging. Thus, there will be high demands on the landscapes of the future, which will have to serve simultaneously the following functions: ecological ,as an area for living, economic, as an area for production, socio-cultural, as an area for recreation and identification, historical, as an area for settlement and identity, and aesthetic, as an area for experiences (Bendict and Mcmmahon, 2002). Depending on people's different ways of using the landscape, it has a different meaning for them. In this regard, landscape is a very complex phenomenon. Single disciplines can only discover and describe small parts of the landscape as a whole. To understand landscape fully and address its challenges, discrete disciplines have to work together (Malpas, 2011). Urban landscapes are landscapes of urban areas, which are the focus of various local economic and socio-cultural activities. They consist of landscapes of settlement areas, which include housing, commercial, institutional, and industrial areas. The problems with maintaining these land uses with traditional methods are numerous. Maintenance can be very labor and resource intensive, thus costly. As it was mentioned in, landscape textbooks that it is so much more expensive to create and operate 'designed' landscapes constructed parks and landscapes that are mowed or regularly cleaned up than natural landscapes, those which are left alone, except for the occasional trail (Tilley, 2002).

2 Sustainable urban landscapes, definitions, Importance and principles

2.1 *What do we mean by sustainable urban landscapes?*

According to the Chambers Dictionary (1993), to sustain means "to hold up, to bear, to support, to keep going, to support the life of and to prolong " while sustainability means" that which is capable of being sustained"(Benson & Roe, 2000: 32). It was suggested by many researches, that something is sustainable if it is possible to support it, to keep it going or in existence, over a significant period of time. (Chiesura, 2004) claimed that sustainability refers to "the continuing ability of the planet to meet the needs of its living inhabitants". The word 'sustainability' can be similarly ambiguous and flexible. It is simple and sensible to work with the most well known and accepted definition from the Brundtland Commission, a United Nations convened initiative that addressed a growing concern about a perceived deterioration of the human and natural environment (Gairola and Noresah, 2010). In 1987 this Commission defined sustainable development as development that 'meets the needs of the present without compromising the ability of future generations to meet their own needs' (World Commission on Environment and Development) (Cadenasso and Pickett, 2008). Landscape may be characterized by, being the embedded heterogeneity of interacted ecological systems; is the special structure of topography, vegetation, land use and human habitation pattern; is an organization of extended upward ecosystem; is the overall system integrated with human activities and regional land; is a beauty scene. Its aesthetic value determined by the culture (Benson and Roe, 2000). Landscape has become a major issue in spatial policy both as a sector in its own right, important to outdoor amenity and the leisure economy, and, increasingly, as a basis for framing and managing wider socio-environmental systems (Antrop, 2005). This trend reflects two broad "schools" in sustainable landscape development, one focused on the design and protection of scenic assets and the other emphasizing dynamic multifunctional links between ecosystem services and human well-being (Waldheim, 2006). Given sustainability's centrality to public policy and corporate social responsibility, it is not surprising that analysts are asking critical questions about the nature of "sustainable landscape" (Chiesura, 2004). In relation to landscape architecture and planning, there is a professional subculture that interprets sustainability in terms of low-impact, but physically and socially pertinent, design and a scenic planning subculture that designates and safeguards rural areas on the basis of "natural" aesthetic value (Gairola. and Noresah, 2010). The discourses of these traditions are often quite distinct and lead to varied interpretations of sustainability.

2.2 The importance of sustainable urban landscapes

A sustainable landscape is one where the natural resources are protected, where wildlife habitat is improved and where human uses and maintenance practices do not harm the environment. Native vegetation is used whenever possible, and the use of turf grass is minimized. Maintenance practices are chosen to reduce their impact on the environment, while at the same time save money (Adams and Sierra, 2009). Landscapes that are managed to enhance natural resources and that use sustainable practices have been shown to have numerous benefits, such as (Berman, 2008):

a) Economic Benefits:

Although the economic valuation of urban landscape is difficult, open and green spaces have economic benefits in several ways (CABE, 2004):

1. Their aesthetic contribution to cityscape influences property values. In general, urban landscape elements increase the nearby property value and enhance marketability of real estate (Anonymous, 2010). Accessibility, quality and visibility are basic factors that determine economic value of urban landscapes in this context.

2. Urban landscapes provide employment opportunities during their design, construction and maintenance. The construction and maintenance of urban landscapes also supports other sectors such as playground manufacturers and nurseries.

3. The health benefits of urban landscapes which were summarized above can reduce the costs of national health expenses.

4. Public urban landscapes provide environments for walking, sports and other recreational activities for no cost at all, especially for lower income groups.

5. Green spaces can help energy saving. Right selection and planting of plants can provide cooler environments in summer and warmer environments in winter thus reduce air conditioning expenses.

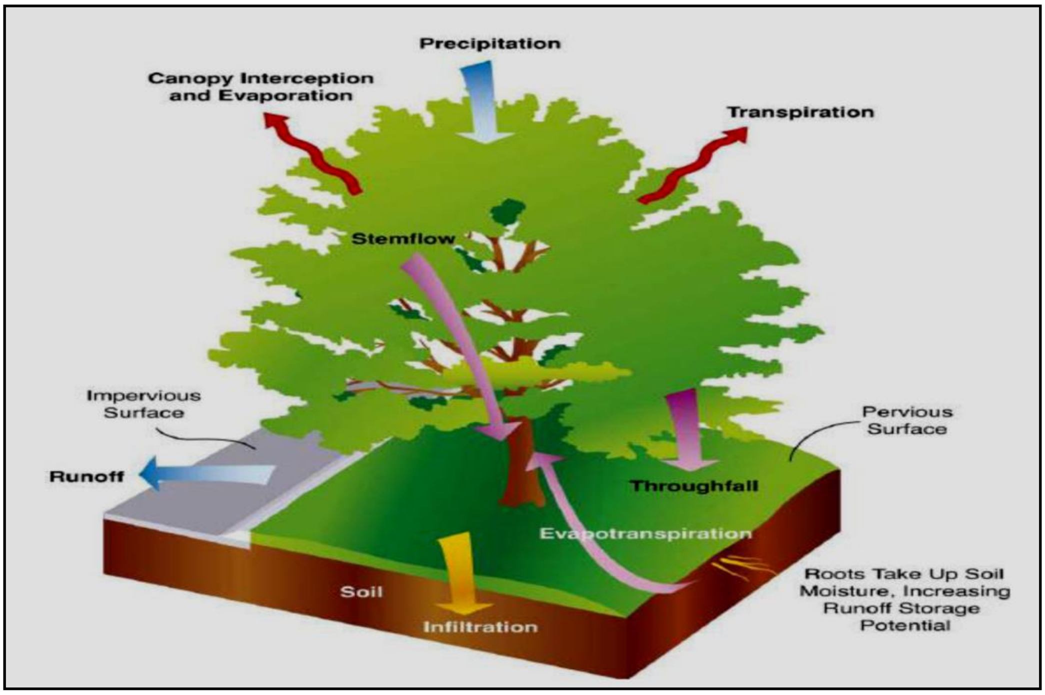
6. Urban landscapes can enhance tourism in cities by attracting people. Park Güell in Barcelona, Spain and Al-Azhar Park in Egypt is a perfect example of how a park can become a global tourism destination.

b) Environmental Benefits:

It was assumed by contemporary urban ecology that urban areas are ecosystems since they have interacting biological and physical complexes (Wong, 2012). However, ecology has been neglected in urban planning systems of most developing countries, which mostly focus on the relationship between physical and socioeconomic aspects of an urban development. Urban green spaces are fundamental in sustaining the urban ecology (Tilley, 2002). Some of the environmental and ecological benefits of the urban landscape are listed below (Sue, 2012):

1. Urban green spaces provide flora and fauna with a habitat to live and therefore support biodiversity conservation.
2. They also act as ecological corridors between urban and rural areas. They support movement of living organisms between these areas.
3. Vegetation cover in urban landscape helps to improve microclimate of urban areas where climate is warmer than their surroundings due to dense built environment and human activities.
4. Vegetation cover raises humidity levels, reduces the stress of the heat island and mitigates the less desirable effects of urban climate. Daytime temperature in large parks was found to be 2-3°C lower than the surrounding streets (Georgi and Zafiriadis, 2006).
5. Vegetation helps to decrease carbon emission levels in cities. Through photosynthesis process in plants $CO2$ in the air is converted to $O2$. Therefore, urban vegetation cover helps to reduce excess $CO2$ in the urban atmosphere. Although the degree of trees' drawing carbon emissions from the air is affected by their size, canopy cover, age and health, large trees can lower carbon emission in the atmosphere by 2-3% (Mikami, and Kubo, 2001).
6. Vegetation covers also filters out other particles and dust in the air. Trees have the capacity to remove pollutants like sulfur dioxide and nitrogen from the air, thus reducing the incidences of asthma and other respiratory diseases.
7. Green spaces absorb and reduce the noise generated by human activities, especially trees act like noise barriers.
8. Vegetation cover and soil in urban landscape controls water regime and reduces runoff, hence helps to prevent water floods by absorbing excess water.
9. Trees can also act like windbreaker.
10. Trees scattered through public landscapes can reduce heating consumption, not only through the cooling processes of evapotranspiration and direct shading, but also by reducing wind spends through surface roughness. Decreasing wind speed reduces the amount of cold air that can flow into a building, which is a major catalyst in the loss of heat during winter (Akbari, et al, 2001). Urban trees are considered a major factor in providing cooling, via shade and evapo-transpiration, and are estimated to offer over 950 MJ (almost 270 kWh) cooling per day, per tree, due to evapo-transpiration effects alone (Mikami and Kubo 2001). Despite the potential for urban vegetation to provide cooling, effectiveness relates to soil water availability.
11. According to the University of Washington's Center for Urban Horticulture (Akbari,et al, 2001), a mature tree canopy can reduce air temperature by five to ten degrees, while the addition of blacktop and other hard, non-porous surfaces contribute to higher temperatures. The evaporation from one large tree can produce the same cooling effect of 10 room-size air conditioners operating 24 hours a day (Figure 1), explains the environmental benefits of trees.

Figure (1) *The environmental benefits of tree. (Source: Akbari, et al, 2001)*



c) Social and Health Benefits:

Trees and green space in urban and community areas can create a positive image and provide an aesthetically pleasing experience for residents. As evidence grows of the vital role that parks play in supporting our health, experts are urging stronger partnerships between the health sector and park and recreation services (Berman, 2008). Although the importance of physical activity for human health is well understood, the vital role that parks play in providing an outlet for this physical activity has only recently been acknowledged (Dunnett, et al 2002). Parks, playgrounds, greenways, trails, and community open spaces help keep residents and their communities fit and healthy. Parks have a role to play in low-income areas, which often have less access to parks than those in more affluent suburbs. One of their key messages is that parks increase 'social capital'. That is, when people work together in a community garden or help create a park from vacant land, they get to know one another, trust one another, and look out for one another (Benson and Roe, 2000). In the last century urban landscapes were referred as being “lungs of the city”, which emphasizes their physical health benefits for urban citizens. As mentioned previously, urban vegetation cover provides a cleaner environment (Bell et al 2005). The old vision of street trees, parks, and public green spaces are regarded as ways to beautify the communities and make life a little more pleasant, these days, their function has been changed from a visual scenatic function to an additional environmental aspect. In summary, sustainable landscapes not only have tremendous value for the environment and wildlife habitat, but also for human health, safety and the state of the economy. When creating new, or enhancing old parks, housing developments and other landscapes, focusing more attention towards natural resource conservation and sustainability is a step that can improve the quality of life for everyone in a community (Figure 2) explains in the roles and functions of the urban landscapes within the sustainability cycle.

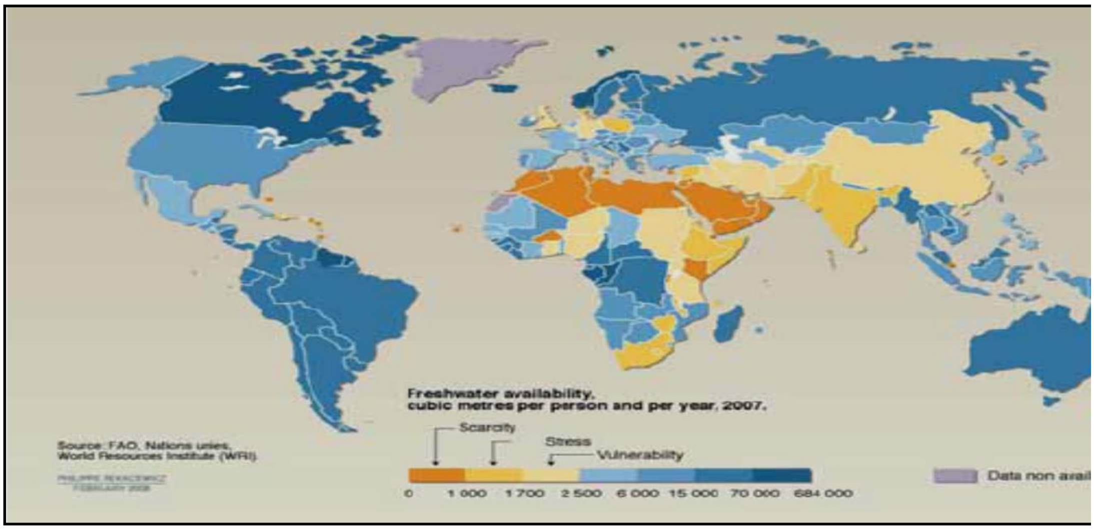
2.3 *Urban landscape sustainability principles*

The principles of sustainable landscape design recognizes the interconnection of natural resources, human resources, site design, building design, energy management, water supply, waste prevention, and facility maintenance and operation (Rahnama and Razzaghian, 2012). According to Benson and Roe (2000) a sustainable design should be well-designed to suit local environmental conditions; contains carefully selected water wise plants; contains plants that will not become environmental weeds; conserves water by using mulch, efficient irrigation, watering only when necessary and grouping plants with similar water needs together; provides habitat for local native fauna such as small birds, butterflies, bats, lizards and frogs; avoids use of pesticide or other chemicals that could harm the natural insect populations and other beneficial organisms; consumes minimal non-renewable energy in construction and maintenance; uses sustainable and locally sourced materials and products, and avoids materials such as rocks, pebbles or wood collected from wild landscapes. The key principles of sustainable landscaping are to design to suit local environmental conditions, water wise or water appropriate plant selection, non-invasive plant selection, and practical water conservation measures. Also, the provision of habitat for local native fauna. The minimal use of pesticides and harmful chemicals and minimal requirement for non-renewable energy consumption is a must. In addition, to using of locally and sustainable sourced materials and products (Malpas, 2011).

3 The Role of Water in the Sustainable Urban Public Landscapes (SUPL)

As water demand continues to grow, and with it the scarcity of renewable natural water resources, we will need to find alternative water sources to complement better water management measures (Domene and Sauri, 2006). Potable water is a finite resource. Water is part of the hydrologic cycle and is the only molecule that can be found in three phases at the same time (vapor, water and ice). Yet, the supply is finite even though it cycles between the three phases in our environment. Pollution also continues to affect the supply of potable water. The earth's water supply is only 2.8% fresh water. (0.l6% is groundwater, 0.01% is lakes and streams, 2.2% is glaciers and icecaps, and 0.01% is water vapor.) The remainder, 97.2%, is salt water. The world is in the midst of a major transition in water management and use (Niemczynowicz, 1999) (Figure 2), shows the water scarcity worldwide.

Figure (2) *The World water map showing the amount and availability of water. (Source: BSRP 2007)*

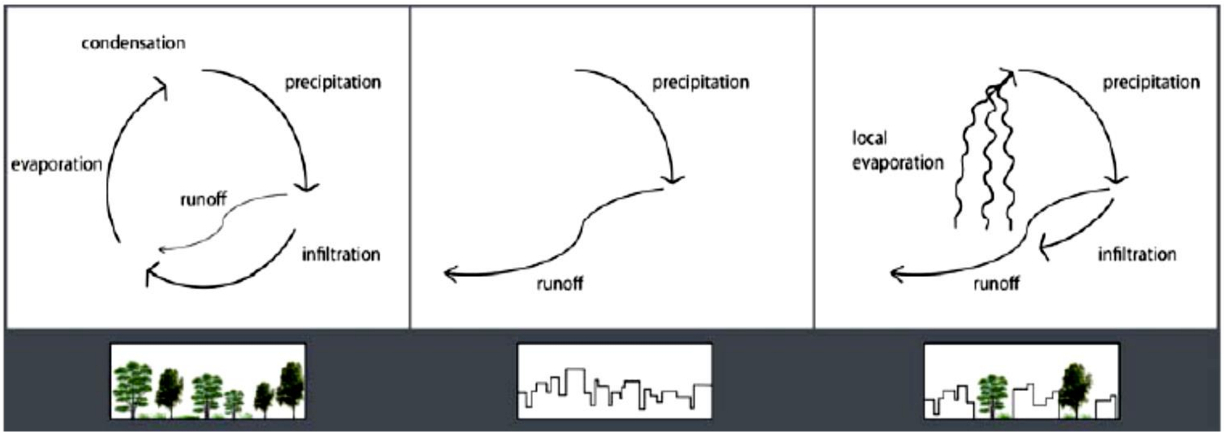


According to Shepherd (2006), over the past century, the construction of massive infrastructure in the form of dams, aqueducts, pipelines, and complex centralized treatment plants, funded with a limited set of financial tools and approaches, dominated the water agenda. This “hard path” approach focused on expanding water supply brought tremendous benefits to billions of people, reduced the incidence of water-related diseases, expanded the generation of hydropower and irrigated agriculture, and moderated the risks of devastating floods and droughts. But the hard path also had substantial, often unanticipated social, economic, and environmental costs.

3.1. Water in the urban landscape planning process

Water is referenced in different ways by many disciplines including design, planning, ecology, geology, anthropology, psychology, sociology, mythology, religion, art, literature and history. But the common thread among all the disciplines is that water is universally perceived as a favorable element. More than anything else, water is a source of life and great symbol for life. It is determined to be critical for human survival. It is considered powerful, and it has been here, in relatively the same quantity understanding the relationship between human needs and the use of water in landscape design and form since the planet's beginning. Urban green spaces can have a positive impact on the hydrological characteristic of urban catchments. The hydrology of urban areas have been highly modified by constructed impervious surfaces such as roads and roofs which increase the velocity and volume of run-off from urban catchments (Shepherd 2006). Water appears in the urban public landscapes in various forms such as, Wastewater and gray water managed by urban sanitation systems; Drinking (Potable) water for daily use (drinking, cooking); Storm water that needs to be drained from hard surfaces (roofs, streets, etc.) to prevent flooding and keep streets and buildings dry and safe; Natural water bodies (e.g. rivers, lakes, brooks); and artificial water bodies and features in open spaces (e.g. fountains, water basins, water streams) contributing to the amenity of cities (improving micro climate, reducing dust and air pollutants, and providing recreation) (Domene, Sauri, 2006). Water plays a significant role in everyday life. Aside from exceptional experiences such as flood and drought disasters, most people are not aware of the function of water. Conventional methods for water management fail to help the city to promote the importance of water resources (GIWE, 2011). Under natural conditions, water operates in a cycle of precipitation, infiltration, surface runoff, and evaporation. However, in urban areas, this cycle is disturbed and cannot run its course. Urban water is polluted, cannot infiltrate the ground due to paved surfaces and is rapidly collected and discharged to the public draining systems leaving no time for evaporation as shown in (Figure 3). Finally, this negatively impacts groundwater recharge, water supplies, the qualitative and quantitative state of receiving rivers, and urban climate. Urban green space impacts significantly on the micro-climate of a region by modifying extremes of climate, improving the hydrological cycle and improving plant health and biodiversity and adding to soil stability (Hoyer, et al, 2011) Most of these advantages are dependent on the vegetation being maintained by irrigation during drought. Water is an essential element in any ecosystem. Yet, it is a very critical feature in arid ecosystems where water is scarce with evaporation exceeds precipitation also the amount of rainfall is frequently low and untimely distributed. Water efficiency in the landscape planning process means: The planned management of potable water to prevent waste, overuse, and exploitation of the resource. In that sense, effective water-efficiency planning seeks to 'do more with less' with no sacrificing performance (Adams, and Sierra, 2009).

Figure (3) *Water cycle in natural systems (left): in an urban area (middle) and in an urban area with urban public landscapes (Source: The author, after Hoyer, et al, 2011).*



Thus, water management policies in arid landscapes, like in our case in Cairo, should be liable to address two related targets: (a) controlling features of the water resource, especially quantity, quality, and timing; and (b) preservation of landscape elements. Several studies were carried out concluded that urban evapotranspiration is a substantial component of the water balance (GIWEH, 2011). These studies found that the amount of water used in evapotranspiration was almost twice the amount of water that was lost from the studied area through run-off. By adding water to the urban landscape, quantifiable benefits in the form of cooler air temperature and energy consumption savings will result (Hoyer, et al, 2011). In the urban context, there is an aim to better tune the impact of urban development on the natural water cycle. The main task is the establishment of an inner, urban, water cycle loop through the implementation of reuse strategies. To this end, the understanding of the natural pre-development water balance and the post-development water balance is of a great importance (BSRP, 2007). An integrated urban water management system encompasses the three principal water streams: potable and non potable water supply, storm water drainage and wastewater disposal (Domene and Sauri, 2006). It implies integration of water conservation, a seasonal storage system, storm water management, a peak storage system and wastewater disposal, a purification system into one system and their decentralization into drainage and water/wastewater management clusters (Connellan, 2005). Water conservation and reclamation can be located near the point of use and, like this, in-puts out-puts regulations with their long distance transfers can be minimized. Planners and designers are therefore asked to investigate new strategies and tools for integrating water and its infrastructures in urban life and in the image of the city (Adams, and Sierra, 2009). Saving water, reducing paved surfaces, retaining and infiltrating rainwater, preventing water pollution, reusing and recycling water and other integrated and decentralized measures are imperatives to be tested, improved and implemented in the context of modern and livable cities (GIWE, 2011).

3.2 Water as a visual element in landscape design

In the visual landscape, water is a common and abundant element not unlike earth and rock. But what distinguishes water from other landscape elements is its unique ability to be molded, sculpted and re-channeled. It is ever-present in the landscape and its malleable form provides the designer with unlimited opportunity**.** However, water features are generally placed in the landscape simply to fill an empty space or to reroute the water to a more convenient place with no forethought as to the meaning or value people place on water. Surely these uses of water do not enrich the environment; they merely fill a space (Malpas, 2011). The manner in which water is presented is crucial for success of the water feature. Incorporating the reflective quality of water in the design, preferably with vegetation, sky or natural forms confirms the presence of life in the user's surroundings. For example, lighting both daylight and night lighting, is an element, which will add excitement, dimension and usability to a water feature as seen in (Figure 4). While night lighting adds drama to the feature and extends the number of hours that the feature can be used, underwater lighting adds an intriguing dimension to the feature. Pure water is odorless, colorless, and tasteless. Yet in the landscape, water often appears in different colors from opaque dark gray to brilliant blue to clear. The apparent color of water changes with lighting, the diurnal and seasonal positions of the sun, with cloud cover, and with particulates carried in the atmosphere or in the water. (Figure 5) illustrates these visual characteristics, which are more extreme and dramatic in arid landscapes (Shepherd 2006).

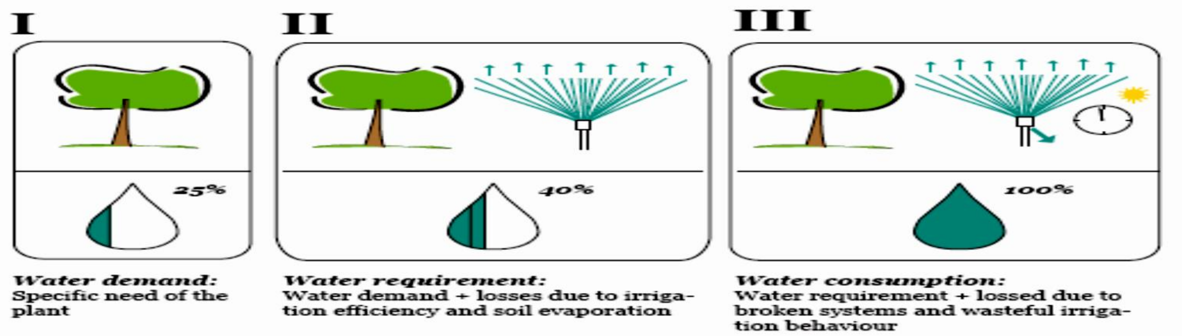
Figure 4: Examples of uses of water lighting both daylight and night lighting. (Source: ASLA 2009).

Figure (5) *Examples of uses of water as a visual element in landscape design. (Source: ASLA 2009).*

3.3 Water as the main source of life in the landscape design process

The most important issue about water function in landscape design apart from its scenatic value, the quantity of water required for irrigating any project. A water budget quantifies all the water flowing into and out of a defined area, such as a watershed or a local park, over a fixed period of time (ASLA, 2009). A water budget looks at precipitation rates, the infiltration of water through the soil, which depends in large part on the amount of non-porous surfaces like roads, evaporation, and the various water users in the area (Georgi, & Zafiriadis, 2006). A water budget can show how much water will be needed for things like restrooms, drinking fountains and irrigation, versus how much water is available. The amount of water being used will depend on factors such as the efficiency rating of faucets and toilets, the time of year (water use is typically higher in the spring and summer) and a whole host of site specific conditions (Connellan, 2005). As illustrated in (Figure 6), the amount of water available will depend on precipitation rates, groundwater levels and stored water. Knowing the amount of water in an area will help to make decisions on how to use and preserve water resources. A sustainable landscape will ensure that human uses of water do not negatively impact the water available for wildlife, plants and the environment. According to (Deister, 2013), there are several systems for calculating the water demand for landscape irrigation, one of the most popular is the University of California Cooperative Extension and California Department of Water Resources 2000, system which is commonly used in order to calculate the water demand for irrigation of any public space.

Figure (6) *Definition of water demand, water requirement and water consumption (Source: Deister, 2013)*



Within this method, the water demand of the planting comprises the demand of the different species, the density of the planting, the microclimate and the reference evaporation rate of the site. To calculate the water requirements, also irrigation efficiency and potential soil evaporation losses are taken into account. These calculations can serve as estimations, but field adjustments as well as upward adjustments due to low water quality, e.g. if reclaimed water is used might still be necessary. Besides, special planting situations, e.g. newly planted or well established planting or trees in turf, can influence the amount of water required for irrigation. Table 1 shows the formula and explains its components.

Table (1) *The water demand formula and its components. (Source: Auth after, Deister, 2013)*

Water Requirement Calculation Formula	**Formula Components**
Formula to calculate the water demand of a planning **(ETL)**	**(ETL= KL* ETO)** **ETL**= Landscape evapotranspiration (water demand) **KL**= Plant coefficient **ETO**= Reference evapotranspiration
Calculation of plant coefficient **(KL)**	**KL**= Ks* Kd* Kmc **Ks**= Species factor **Kd**= Density factor **Kmc**= Microclimate factor

Up to now, engineers, ecologists, landscape architects, planners and other professionals have generally adopted divergent approaches and standards to the issue of water. However, nowadays, the perspective is changed. Water-related outcomes have to be interrelated with other sustainability objectives that should be included in the urban development and re-development processes. (Dunnett, et al 2002), Besides, the concept of sustainable development stimulates two levels of integration: firstly, the integration of all waters of the water cycle (storm water, groundwater, surface water but also drinking water and wastewater); secondly, the integration of those disciplines and institutions involved in the organization and maintenance of water cycles and related infrastructures (Poulton, 2000). Such a comprehensive approach opens up to more cross-disciplinary opportunities and less generic standardized and normative "solutions". One of these solutions a key strategy that reduces demand, gray water reuse is an important strategy in improving the resilience of water systems to the impacts of climate change (ASLA, 2009). In addition, gray water reuse can also be considered a relatively secure or drought resistant source of water supply because presumably, gray water generated from showers and washing machines will continue, if at a reduced rate, in the future. Reuse of graywater can help displace demand for water, thus reducing conflicts over water and reducing the demand for new water supply projects (Sue, 2012).

4 A Suggested Methodology for Evaluating the Sustainability of UPL

In order to have a sustainable urban public landscape, it is suggested that several measures may be used to evaluate its sustainability depending on the water efficiency as the component with the relatively high weight in evaluation. The evaluation procedures may be as follows, as shown in Table 2:

Table (2) *The Evaluation checklist for sustainable urban landscapes SUPL. (Source: Author, after Anon, Crossam Georgi, & Zafiriadis, Cadenasso, & Pickett, Poulton).*

SUPL EVALUATION ELEMNTS	CRITERIA OF EVALUATION
Water Efficiency	1. Water wise or water appropriate plant selection. 2. Limiting or eliminating the use of potable water, or other natural surface or subsurface water resources available on or near the project site, for landscape irrigation. 3. Using modern strategies to eliminate the use of potable water in irrigation such as desalination and graywater systems. 4. Using storm water or recycled rainwater in irrigation of public spaces. 5. Enhancing irrigation systems by using soil moisture sensor, water pressure regulators and rotary nozzles which overcomes spray deflection broken heads, tilted and sunken sprinklers, arc misalignment and non-rotating heads. 6. Reduction in distribution informality, as poor uniformity leads to longer run times of irrigation causing water inefficiency.

Softscape-Vegetation	1. Using Vegetation cover to improve microclimate of urban areas where climate is warmer than their surroundings due to dense built environment and human activities. 2. Raising humidity levels, reducing the stress of the heat island and mitigates the less desirable effects of urban climate. 3. Decrease carbon emission levels through photosynthesis process in plants CO2 in the air is converted to O2. Therefore, helps to reduce excess CO2 in the urban atmosphere. Although the degree of trees' drawing carbon emissions from the air is affected by their size, canopy cover, age and health, large trees can lower carbon emission in the atmosphere by 2-3%. It also filters out other particles and dust in the air. 4. Softscape absorb and reduce the noise generated by human activities, especially trees act like noise barriers. 5. Vegetation covers and soil in controls water regime and reduces runoff, hence helps to prevent water floods by absorbing excess water. Trees can also act like windbreaker. 6. Trees scattered through public landscapes can reduce heating consumption, not only through the cooling processes of evapotranspiration and direct shading, but also by reducing wind spends through surface roughness.
Biodiversity (Habitats & Ecosystems Conservation)	1. Providing flora and fauna with a habitat to live and therefore support biodiversity conservation. 2. Acting as ecological corridors between urban and rural areas. They support movement of living organisms between these areas. Also protection and restoration of habitats.
Innovation in Design	1. Design is done to suit local environmental conditions. 2. Application of the general design principles of simplicity, balance, unity and harmony, scale ratio and proportion, as well as visual interest. 3. In addition to fulfilling all functional requirements.
Site & Resources Management	1. Use of locally and sustainable sourced materials and products. 2. Minimal use of pesticides and harmful chemicals. 3. Minimal requirement for non-renewable energy consumption. 4. Using pores surface hardscape helps water penetration to existing soil and form a ground water reservoir.

5 The Egyptian Experience in SUPL

As mentioned earlier, the urban public landscape open spaces can range from playing fields to highly maintained environments to relatively natural landscapes. They are commonly open to public access, however, urban open spaces may be privately owned. Areas outside of city boundaries, such as state and national parks as well as open space in the countryside, are not considered urban open space. Streets, piazzas, plazas and urban squares are not always defined as urban open space in land use planning. The value of urban open space can also be considered with regards to the specific functions it provides. Kafafy (2010) drew up a detailed analysis of the amount, the distribution and also the kind of UPL, which can be found in Cairo. He analyzed different neighborhoods, their urban pattern and the resulting green open space facilities. One very interesting finding is that according to Kafafy's estimations, 67% of the green open spaces in Cairo are privately owned, while only 33% are provided by the government. In addition, just 1/3 of those 33% of public green open spaces are free to enter. (Kafafy 2010: 88). Egypt has reached a state where the quantity of water available is imposing limits on its national economic development. As indication of scarcity in absolute terms, often the threshold value of 1000 m^3/capita/year is used. Egypt has passed that threshold already in nineties. As a threshold of absolute scarcity 500 m^3/capita/year is used, this will be evident with population predictions for 2025 which will bring Egypt down to 500 m^3/ca/yr. The actual resources currently available for use in Egypt are 55.5 Billion Cubic Meter (BCM)/ year (yr), and 1.0 BCM/yr effective rainfall on the northern strip of the Delta, non-renewable groundwater for western desert and Sinai, while water requirements for different sectors are in the order of 75 BCM/yr. The gap between the needs and availability of water is about 20 BCM/yr. This gap is overcome by recycling (Yassin, 2013). In addition in Cairo public landscapes, due to the inefficient irrigation systems used, the excess water, which occur due to the wrong location of sprinklers leading water to travel over hard surfaces like pavement and carry away fertilizers that could promote the growth of algae and invasive plant species. Also, when pesticides are improperly used or disposed of, any excess pesticide could potentially reach drinking water supplies and could harm humans and native plants. In addition to maintenance practices, the design of these areas is not always helpful to conserving and enhancing the natural environment. Roads and parking lots fragment habitats. Plants are chosen for their looks rather than their wildlife benefits, and human uses like recreation and industry can degrade or eliminate habitat for most animal and plant species (Deister, 2013). Furthermore, a site's geology and soils may not naturally support the chosen plants. So as development pressures rise, wildlife have nowhere to go, with all the turf yards, shopping plaza parking lots and freeways taking up all available habitat, creating an unbalanced landscape. These days, in Egypt, the manifold dimensions of sustainable landscapes raise challenging questions over the nature of how to design, plan, and manage them. The matter is further complicated by a variety of traditions and subcultures and by the different scales and concerns of urban and landscape practitioners (Yassin, 2013). However, some common themes emerge around the canons of sustainability. Further, there is a growing acknowledgement of the importance of all landscape, not only that deemed "outstanding" in terms of natural beauty. Also, people may not be comfortable with sustainable landscape; adjusting to it may take time. However implementing just one or a few principles of sustainable design can significantly provide less environmental decline. The benefits may include also; more effective use of water, pesticides and other chemical resources; more valuable wildlife habitat; enhanced landscape beauty; and cost savings from reduced maintenance, labor and resource use (Deister, 2013).

5.2 Applying the Suggested Methodology on Cairo SUPL

This evaluation methodology was carried out among a sample of 10 public parks and 5 streetscapes. In order to demonstrate the purpose of this research, six cases were selected, five parks and a streetscape based on a number of site visits, detailed survey for plant species and typologies inspections and meetings with experts, mangers of these landscapes. Also, the water consumption of each case was calculated based on a simplified version of the water demand formula mentioned earlier. These cases are:

Case Study 1: Al-Asmak Garden, which is considered to be Cairo's aquarium. It is located in the Zamalik Island with a total area of almost 12 feddans. The main purpose of design was to demonstrate all types of sea life. It consists of caves hosting the aquarium as well as a main hilly shaped plateau as a landmark for the whole park. Hardscape is dominant although the material used is non-porous which has negative impacts on the hydrological cycle. When applying the Water Demand Calculation Formula the park water consumption is 300 m3 per day, which is considered moderate in consumption (Figure 7).

Case Study 2: Al-Orman Garden, which is considered Cairo main Botanical Park. It is situated in front of Cairo University and through history; it was connected with the Giza Zoo and was separated due to planning purposes. The park total area is around 35 feddans. It hosts all native and non-native plant species, the concept of design main purpose was to demonstrate the various types of vegetation in a scientific order. When applying the Water Demand Calculation Formula the park water consumption is 1700 m3 per day, which is considered very high in consumption (Figure 8).

Case Study 3: Al-Fostat Garden, which is considered one of Cairo biggest public parks. It is situated in Masr Al-Kadima with a total area of almost 38 feddans. The park landscape design is very simply, with massive lawns areas and large tree patches, with some hardscape plazas. When applying the Water Demand Calculation Formula the park water consumption is 1300 m3 per day, which is considered very high in consumption (Figure 9).

Case Study 5: Al-Orouba Garden (Japanese Cherry Garden), this park is located on Cairo's main road to the airport. The park was considered to a brown field transformation, as the area of the park, which is almost 2.5 feddans, was solid waste and garbage collecting area. The main design consist of a simple walk way trail and lush green lawn hosting some none native plant species which is the Japanese cherry tree, which was donated as gift to the Egyptian Government by the Emperor of Japan. When applying the Water Demand Calculation Formula the park water consumption is 100 m3 per day, which is considered very high in consumption, taking into consideration that main source of water is gray water (Figure 10).

Case Study 4: The Child Park garden, which is located in Nasr City. The planning of Nasr City was done to host several community gardens; the Park is one of them with a total area of almost 22 feddans. The design of the park was done to accommodate several community activities such as a children play area, library and mini funfair. The vegetation cover is considered to be semi-lush a mixture of green lawns and large tree surrounding the park circumference. When applying the Water Demand Calculation Formula the park water consumption is 750 m3 per day, which is considered very high in consumption, taking into consideration that main source of water is potable water (Figure 11).

Case Study 6: Autostrad Road, (10000000 tree sector) this project was targeting greening a vehicular axis as an initiative for saving the environment and creating green environment in the desert environment around the airport. The project acted as a turning point regarding the lands surrounding the project and the large scale of investment that appeared based on this project. One of the basic concepts was to create a middle park (island) that people could use rather than the narrow sidewalks. The area of vegetation is limited to the middle island of the street only. It has many ornamental plants. The types of trees are not changing much along the axes. The most are a grass cover, plants or shrubs on the boundaries or around the trees. The trees are in the middle or two rows on the sides. The social activity is minimal inside these areas as it is only acting as a good view for the street. The total length of this road is 5 km and the length of this specified sector is 1.5 km. When applying the Water Demand Calculation Formula the park water consumption is 500 m3 per day, which is considered very high. But the main network water source is gray water, which is an asset to the water efficiency (Figure 12).
The evaluation was performed on the selected case studies, reported on by Table 3; a simplification of the items in the SUPL Evaluation Criteria table (Table 2) was done to facilitate the understanding of its components. A grading system was made to evaluate the items according to the following criteria:
High Efficiency grade: this grade is given when the item fulfills the sustainability aspects in general, with emphasis on the water efficiency in particular.
Medium Efficiency Grade: this grade is given when the items does not fit well with the sustainability aspects in general, with emphasis on the water efficiency in particular.
Low Efficiency Grade: this grade is given when the items have negative impact on the sustainability aspects in general, with emphasis on the water efficiency in particular.

5.3 Assessment and Findings of the Case Studies

After reviewing the case studies, from Table 3, the following findings were deduced concerning the existing condition. All UPL suffer some major deficits. Nonfunctional “landscape scenery design” with high maintenance requirements and excessive water consumption are a common finding. Water budget is not a factor in design. There are no solutions for limiting water consumptions of different landscape projects. The application of water reuse, recycle and treatment as solutions for limiting high water usage through landscape is minimal. Different irrigation techniques and control systems for limiting the wasted water through landscape consumption does not exist. Integration of the permeability of the flooring material is not considered in the design. Lack of maintenance for public parks and open spaces is a common case. The concept of edible landscape is absent in application. The density of vegetation and its effect on transpiration and accordingly the water consumption are fields that are always neglected in the landscape design Stereotyped types of vegetation used in all open green spaces in Cairo.

Figure (7) *Case study 1, Al-Asmak garden analysis, showing the water efficiency condition of the garden (Source: by the author).*

Figure (8) *Case study 2, Al-Orman garden analysis showing the water efficiency condition of the garden (Source: by the author).*

__Figure (9)__ Case study 3, Al-Fostat garden analysis showing the water efficiency condition of the garden (Source: by the author).

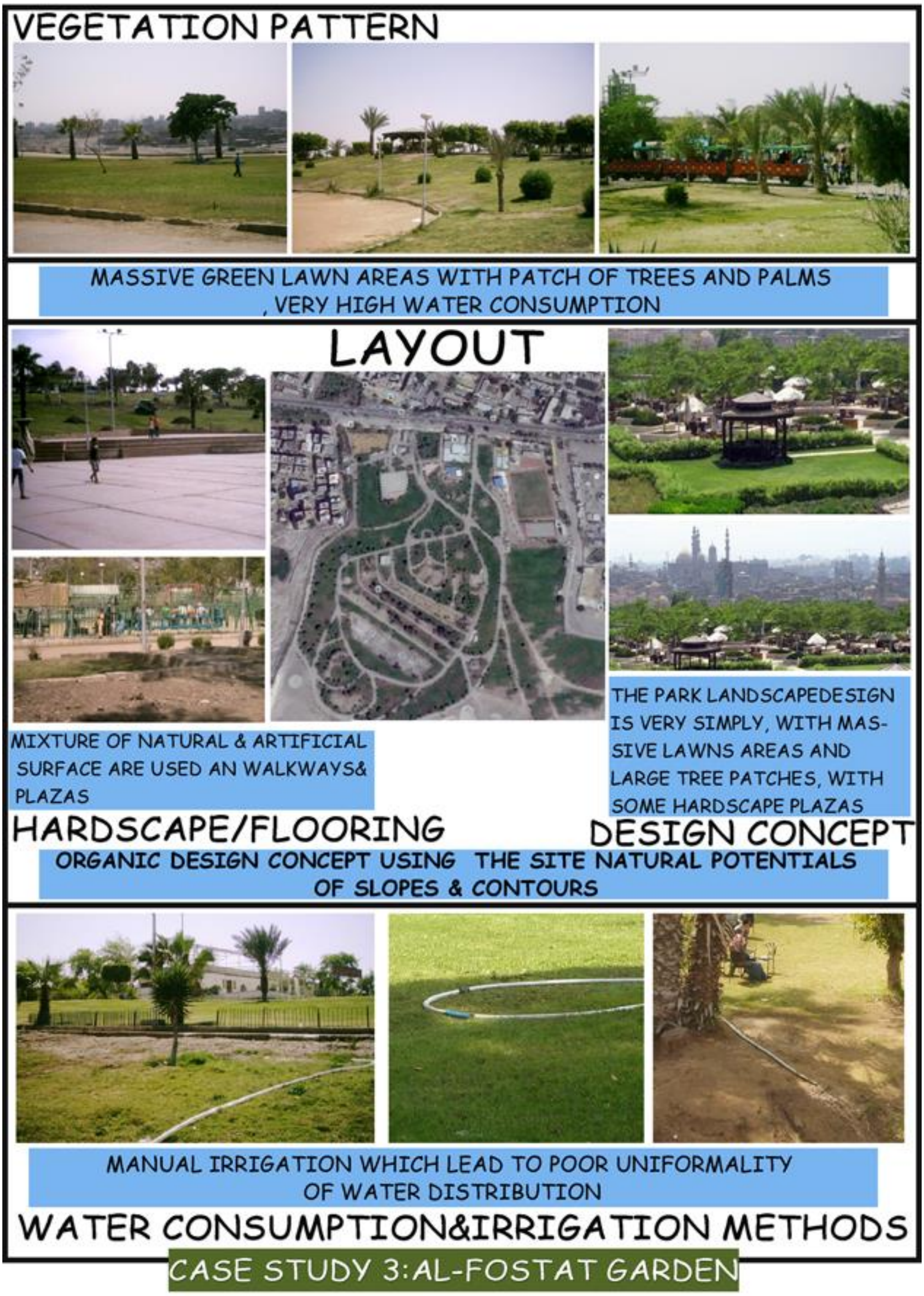


Figure (10) *Case study 4, Al-Orouba garden analysis showing the water efficiency condition of the garden (Source: by the author).*

Figure (11) *Case study 5, Child garden analysis showing the water efficiency condition of the garden (Source: by the author).*

Figure (12) *Case study 6, Autostrade (1000000 Tree sector) showing the water efficiency condition of the garden (Source: by the author).*

Table (3) *Assessments and findings of the six case studies (Source: by the author).*

SUPL Evaluation Elements	Criteria of Evaluation	Efficiency CS 1	CS2	CS 3	CS 4	CS 5	CS 6
Water Efficiency	using potable water for irrigation	yellow	yellow	yellow	blue	yellow	blue
	using modern strategies for irrigation	yellow	yellow	yellow	green	yellow	green
	poor uniformality of water distribuition	green	yellow	yellow	green	yellow	green
	water consumption calculation	blue	yellow	yellow	green	yellow	green
Softscape Vegetation	selecting plants with low water consumption	yellow	green	green	yellow	green	blue
	plant mass affecting co2 decrease	blue	blue	green	blue	green	green
	trees effection heat island	blue	blue	blue	blue	blue	blue
	wind breaking effect	blue	blue	blue	green	blue	blue
Biodiversity (Habitats & Ecosystem Conservation)	providing enough flora and fauna	blue	blue	blue	green	green	green
	selecting of native spieces	yellow	green	yellow	green	blue	blue
	green ecological corridor	green	blue	blue	yellow	green	blue
Inovation in design	suitability with local environement	green	blue	blue	green	green	blue
	scenatic value	blue	blue	green	yellow	green	blue
	functionality in design/proper use element of water	green	blue	yellow	green	blue	blue
Site & Resources Management	use of local materials	yellow	green	green	green	green	green
	minimum use of perticides	green	blue	yellow	green	yellow	green
	renewable energy consumption	yellow	yellow	yellow	yellow	yellow	yellow
	recycling solid wastes	yellow	yellow	yellow	green	green	green
	using of porase suface hardscape	yellow	yellow	yellow	yellow	green	green
Total		green	yellow	yellow	green	yellow	blue

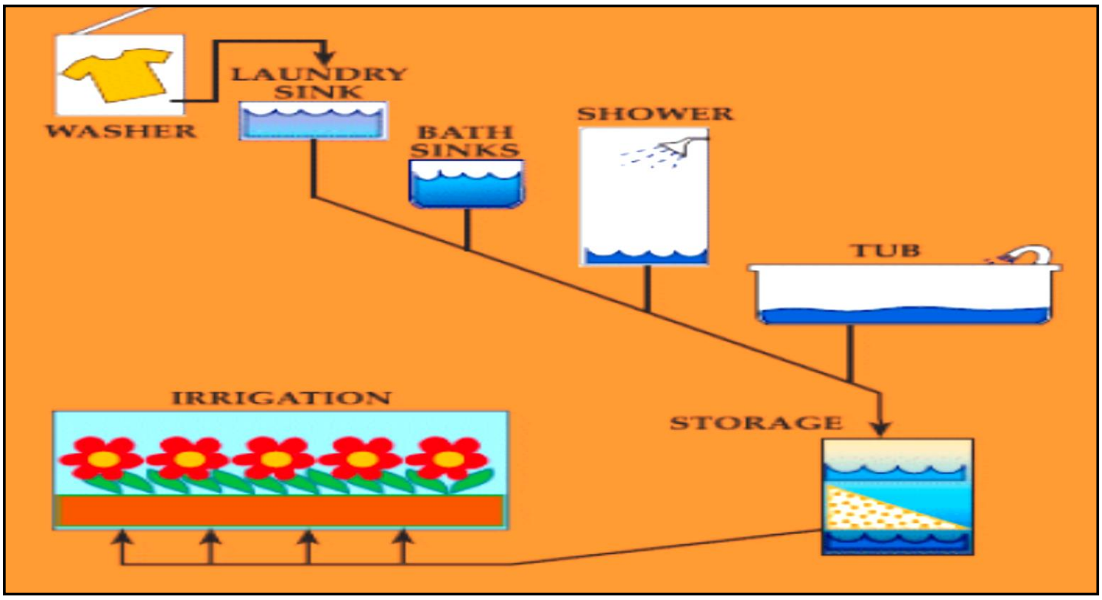
low efficiency (yellow) medium efficieny (green) high efficieny (blue)

5.4 Tools and Methods to Enhance Sustainability and Water Efficiency in Cairo SUPL

In order to overcome the deficiencies the overall sustainability in general and the water efficiency in particular in Cairo urban public landscapes, the following blue print me may suggested:

A) Introducing the Use of Gray water as Main Source of Irrigation: According to Cohen, (2009) Gray water is the untreated wastewater, excluding toilet and, in most cases, dishwasher and kitchen sink wastewaters, as illustrated in (Figure 13). Wastewater from the toilet and bidet is "backwater." Exclusion of toilet waste does not necessarily prevent fecal matter and other human waste from entering the gray water system, albeit in small quantities. Examples of routes for such contamination shown in (Figure 14) include shower water, bathwater, and washing machine discharge after cleaning of soiled underwear and/or diapers. California's latest gray water standards define gray water as: "gray water" means untreated wastewater that has not been contaminated by any toilet discharge, has not been affected by infectious, contaminated, or unhealthy bodily wastes, and does not present a threat from contamination by unhealthful processing, manufacturing, or operating wastes. "Gray water" includes but is not limited to wastewater from bathtubs, showers, bathroom washbasins, clothes washing machines, and laundry tubs, but does not include wastewater from kitchen sinks or dishwashers" (Bahman, 2010: 1-2).

Figure (13) *Sources of Gray water for landscape irrigation. (Source: Cohen, (2009).*



Gray water use is not something new to our communities. In rural areas throughout the world, reuse of water that has already been used for washing, cleaning, and bathing has always been a common practice. With the advent of piped water systems and wastewater collection networks, this practice diminished in importance, especially as communities grew denser and increasingly urbanized in the 20th century. Population explosion, especially in the arid and semi-arid regions of the world, has exerted a tremendous stress on available water resources. People have responded to water rationing, elevated water costs, and calls for water conservation with ingenious methods beyond those "best management practices" (BMPs) advanced by their water purveyors. Gray water reuse is indeed a rediscovery of a very ancient practice, one that went out of style because it was deemed unsanitary, potentially dangerous to public health, and needless because of the availability of cheap, seemingly limitless tap (potable) water and easy wastewater disposal (Zoubi et al 2012). Each episode of drought in the past 50 years has brought about a surge of new advocates and users of gray water with various levels of sophistication (Travis et al., 2010). Users of the simplest of gray water systems carry the warm-up water from the sink or bath to throw on their landscape plants. Others concoct plumbing systems that capture washing machine effluents.

Users of still more elaborate systems build a second drainage system in their residence to capture nearly all gray water sources and lead the water to storage tanks, treatment systems, and application to the irrigated landscape areas on the property. While, what is called Backwater is collected in a separate sewer and sent to the central treatment plant. Effluent from the onsite treatment system is then utilized as non-potable recycled water in a manner similar to that for recycled water. The rationale for such systems is that (a) gray water sources within the building provide enough water for the non-potable water demand in the building and its vicinity and (b) the lower solid loading, BOD loading, and microbial content of gray water make treatment less costly and less energy-intensive (Cohen 2009). In order to overcome the accusations for gray water being dangerous for public health the following precautions should be considered (Zoubi et al 2012):

1. First and foremost, avoid human contact with gray water or with soil irrigated with gray water.

2. Use gray water for household gardening, composting, and lawn and landscape irrigation, but use it in a way that it does not run off your own property.

3. Do not surface irrigate any plants that produce food, except for citrus and nut trees.

4. Use only flood or drip irrigation to water lawns and landscaping. Spraying gray water is prohibited.

5. Gray water may be used only in locations where groundwater is at least 5 ft. below the surface.

6. Label pipes carrying Gray water under pressure to eliminate confusion between gray water and drinking water pipes.

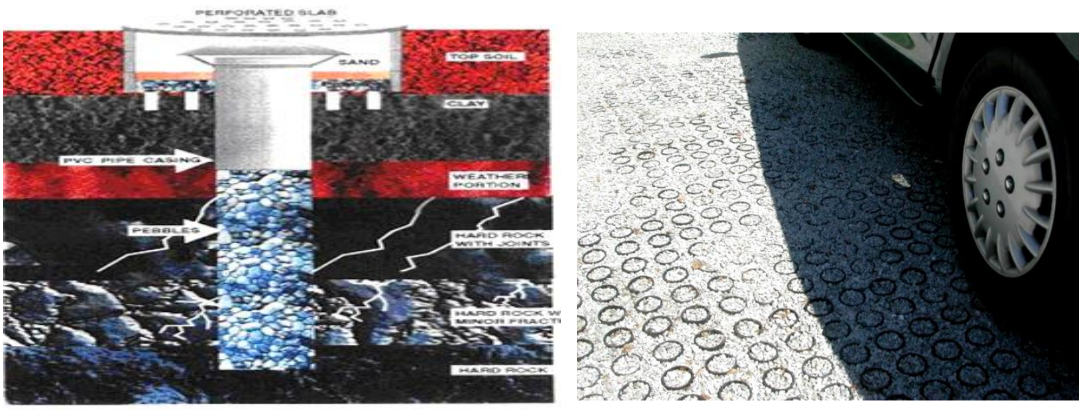
7. Gray water from washing diapers or other infectious garments must be discharged to a residential sewer or other wastewater facility, unless it can be disinfected prior to its use.

8. Surface accumulation of Gray water must be kept to a minimum.

One of the significant incentives for reuse of Gray water in future landscaping of our parks is the point credit system used by green building certification organizations, such as LEED (Leadership in Energy and Environmental Design), developed by the U.S. Green Building Council (USGBC) (Travis et al., 2010). This system provides a suite of standards for environmentally sustainable projects. Since its inception in 1998, LEED has grown to encompass more than 14,000 projects in the United States and 30 countries covering 1.062 billion square ft. (99 km^2) of development area (Cohen 2009). LEED is an internationally recognized green building certification system providing third-party verification that a building or community was designed and built using strategies aimed at improving performance across all the metrics that matter most: energy savings, water efficiency, $CO2$ emission reduction, improved indoor environmental quality, and stewardship of resources and sensitivity to their impacts. The goal of the Water Efficiency credit category is to encourage smarter use of water inside and out. Water reduction is typically achieved through more-efficient appliances, fixtures, and fittings indoors and through water-wise landscaping outdoors (Zoubi et al 2012).

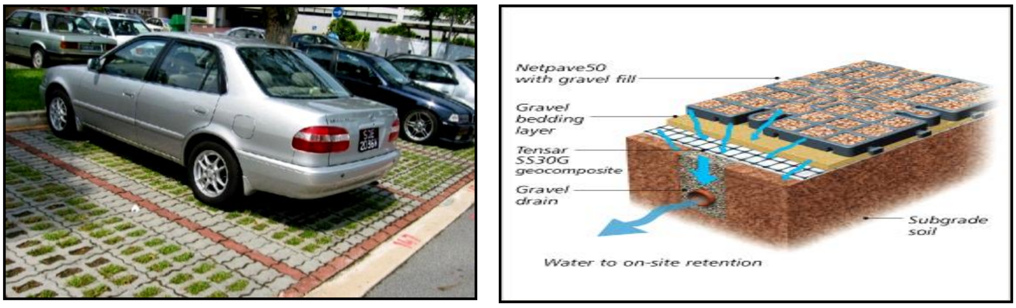
B) Landscape Design Concepts Modifications: All design concepts should take into consideration the water budget calculation as a main constrain while formulating the design concept in order to create water efficient landscapes. Select plant material that can tolerate drought and reflected heat from play surfaces. Plant larger shade trees to provide shade and cooling over play areas. Use products that promote a site's hydrological, soil, vegetative, habitat or climatic health and improve overall ecological functioning. Use products and assemblies that reduce the urban heat island effect. Use products and assemblies that reduce energy and water consumption during site operations. Use porous pavement such as stabilized gravel, porous concrete, porous aggregate unit pavers, stone or concrete unit pavers, and decks in hardscape areas that are suitable for infiltration. Consider clogging of cells in porous pavements as explained in (Figure 14). Possible adverse changes to the soil pH caused by leaching from pavers and crushed stone. Spray features can reduce water use through low flow and misting sprays, and reduce water waste by directing runoff to planted areas (Anon, 2009).

Figure (14) *Use porous pavement and apply water filter hardscape techniques (Source: Anon, 2009).*



Streetscapes should be looked at, as more than transportation corridors, they are also public spaces. By transforming street medians, traffic triangles, and other road configurations into gardens with vegetative and canopy cover, streetscapes can reduce airborne particulates, carbon dioxide, the urban heat island effect, and ground level ozone by reducing ambient temperatures. Trees and other vegetation can provide shading, evaporative cooling, habitat, and storm water capture. Trees, shrubs, perennials, and groundcovers in paved, vacant traffic islands and medians can serve as small ecologically functional areas with a positive cumulative impact to the city's appearance and environmental quality. Planting in the public right of way requires careful site assessment and design. Sub grade compaction, poor soil, poor infiltration rates, and underground utilities are common. For street pavement, consider using porous asphalt to enhance the hydrological cycle. Porous asphalt pavement has been successfully used in low traffic areas for more than two decades these systems allow the penetration of water to the sub-soils and continue the hydraulic cycle as seen in (Figure 15).

Figure (15) *The Porous asphalt pavement for streets and parking lots (Source: Anon, 2009).*



C) Irrigation System Water Efficiency Techniques: Conserve through proper design of irrigation systems and by using high irrigation efficiency application methods and proper pressure regulation, (i.e. high efficiency verses spray irrigation). Conserve 20% - 40% of irrigation water annually by using a “smart” irrigation controller (automatically adjusts run times based on actual weather or soil moisture conditions. Conserve through proper hydro zoning. (Separation of irrigation zones/ stations/ run times according to areas of the landscape with similar water needs based on plant species water requirements, slope/aspect, soil conditions, exposure (sun/ shade), wind, or other microclimate factors.) Preserve by using areas of non-irrigated inert groundcovers/ mulches. A proper maintenance of irrigation systems is required. Also, irrigating during hours with the least evaporation (evening or early morning) (Domene, Sauri, 2006). Use new irrigation strategies such as Gray water, which is the water that can be collected from sinks, tubs, dishwashers, clothing washers, etc. and reused within the landscape. The reusable water is collected by connecting the drain lines to pipes that flow to a sealed filtering tank instead of the sewage system. This tank has an overflow connection to the sewer system with a backflow prevention device, which protects the reusable water. In case the reusable water is not produced in a sufficient quantity, potable water is added to the system to maintain the required water needs of the landscape. Using a properly designed and installed gray water and rainwater capture/harvesting system can utilize up to half of the water used from a home. Upgrading irrigations controllers to weather based or soil moisture sensing “Smart Clocks” will distribute the appropriate amount of irrigation water based on plant requirements, soil type, and actual weather/ soil moisture conditions, thus conserving an estimated 20% - 40% of irrigation water annually compared to standard clocks. Inefficient spray nozzles should be retrofitted with high efficiency irrigation systems. Retrofitting non-functional (purely decorative) turf areas with native species, lower water use plantings, newer hybrids of more water efficient turf grasses, or inert materials such as decomposed granite and decorative gravel will provide additional water conservation (GIWEH, 2011) as shown in (Figure 16).

Figure (16) *Modern techniques in irrigation that helps to improve water efficiency (Source: GIWEH 2011).*

D) Vegetation / Softscape Selection: Conserve by using low water use plant species Native plants typically survive with minimal amounts of supplemental irrigation, are adapted to the climate, and provide habitat for birds and other wildlife species. The planting of native plants where possible and appropriate will contribute to reduction of water use, minimize maintenance, reduce introduced weed species, and provide a regionally appropriate aesthetic compatible with the natural environment. (Figure 17) explains how a self-sustaining native landscape will survive drought and establish itself in perpetuity, intercepting rain in the leaf canopy, increasing water infiltration into soil, slowing surface run-off, reducing flooding, and erosion. A self-sustaining native landscape can self-seed, regenerate and continue to establish which will continually lower maintenance requirements. Native landscapes require little or no supplemental irrigation and require little or no trimming or manicuring.

Figure (17) *Some planting concepts and techniques to enhance the water efficiency and site sustainability (Source: ASLA, 2009).*

6 Conclusion and Issues to be raised

In the 19th century with massive urbanization in Cairo, the continued explosive growth of urban areas and the decline of nature throughout the 20th century, the alienation between people and the nature was increased. Urban public landscapes and related human health issues are a critical component of any state, regional, and local infrastructure plan for livable, just communities. Urban public landscapes in Cairo are the core values at stake in building public infrastructure: providing children the simple joys of playing in the park; improving health and recreation; equal access to public resources; democratic participation in deciding the future of the community; economic vitality for all with increased property values, local jobs, small business contracts, and affordable housing; spiritual values in protecting people and the earth; the environmental benefits of clean air, water, and ground; and sustainable regional planning. Urban public landscapes should be vital places for us to learn, play, grow, and connect with both nature and our neighbors and communities in modern and urbanized society. They refill our air and water; they protect or provide safe havens for Cairo. They may define what a civil society is; they define what a livable city is. The need to achieve a sustainable future is the driving force changing the way we live and work in the 21st century Cairo. Climate change, loss of biological diversity, declining air and soil quality, the spread of pest plants and animals and shortages of drinking quality fresh water all point towards a critical need for this behavior change. Cairo environmental problem is the non-sustainable way we live. The challenge to our generation is to bring about change in a way that is respectful and creative. Our landscapes in Egypt in general and Cairo in particular, are therefore a resource, which is to be used prudently and sustainable; they are the matrix through which, with our design skills and ingenuity, we can accommodate development. The great opportunity for urban communities and urban landscapes is in their potential contribution to a healthy future for urban environments. This means much more than building ‘green’ parks and gardens that function as air-cleansing lungs or places for family fun and fitness. It involves enhancing and promoting modern techniques for getting the best environmental sustainability benefits. As water shortages, droughts, and awareness of water scarcity become increasingly popular topics in the media and public discourse, any measure to reduce demand for water is viewed favorably and given credit for achieving sustainability goals. Gray water is no exception. In fact, Gray water appears to be more favorably viewed by the public at large than are the much more sophisticated water reuse projects proposed in some parts of the world, It is recommended to increase the attention to the use of this concept as a source of water irrigation in landscaping our parks. The need to achieve a sustainable future in Cairo should be the driving force changing landscaping practices. Thus, a well-designed sustainable landscape that reflects a high level of self-sufficiency should be established.

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Effect of building Form, Orientation, and Thermal Insulation on Energy Consumption In Air-Conditioned Desert Buildings.

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Abstract

Passive solar architecture strategies such as adjusting building form and orientation, and using thermal insulation to improve users' comfort are commonly used. Nowadays, an increasing number of buildings are air-conditioned, and some passive techniques may not yield the anticipated energy reduction in these buildings. In addition, some strategies might seem contradictory such as decreasing the exposed surface area of building and that of setting large ones but thermally insulated.

This paper questions the effect of building form and orientation on the energy consumption of air-conditioned low-rise residential buildings in comparison to that of using thermal insulation in external walls for different desert environments. A base case of a squared two-storey residential building was simulated using the Energy-Plus software in three cities: Jeddah, Cairo and Alexandria. It was compared with other building forms: rectangles of different proportions, L, U, H-shaped forms and a squared courtyard building.

Results showed that common desert building forms do not always yield the expected reduction of energy consumption. The un-insulated courtyard building consumed 15% more energy in comparison with the square shaped building in the extreme hot climate of Jeddah, but when insulated, its performance improved to achieve savings of 17%, which was more than the savings achieved by the insulated solid square. This trend was evident to a less extent in Alexandria; the courtyard reached 5% increase of energy consumption, while the insulated one reached 19% savings, to be one of the highest efficiency forms.

The effect of orientation varied according to the proportions of the forms, and thus, to the increase or decrease of the portion of surface area subjected to direct solar radiation. In general, thermal insulation proved to be of a higher effect than building form and orientation in almost all cases.

***Keywords**: Building form, Thermal insulation, energy-efficient, simulation, air-conditioned desert buildings.*

الملخص

من المتعارف عليه معماريا استخدام استراتيجيات التصميم المعمارى السلبى كتشكيل كتلة المبنى و التوجيه و دراسة العزل الحرارى بهدف تحقيق الراحة و كفاءة استهلاك الطاقة داخل المبانى. وفى هذه الآونة تزداد أعداد المبانى المكيفة، وهو ما قد يجعل بعض هذه التقنيات السلبية لا تؤدى النتائج المتوقعة من تقليل استهلاك الطاقة. وبالإضافة إلى ذلك، فإن

تأثير بعض الاستراتيجيات قد تبدو محل تباين مما يثير التساؤل، مثل معرفة أيهما أكثر تأثيرا: الإقلال من مسطح غلاف المبنى المعرض للخارج أم استخدام مسطح كبير مع إضافة العزل الحرارى.

هذه الورقة البحثية تقوم بدراسة تأثير تشكيل كتلة المبنى والتوجيه على استهلاك الطاقة فى المبانى السكنية المكيفة منخفضة الارتفاع، ومقارنته بتأثير استخدام العزل الحرارى للحوائط الخارجية فى بيئات صحراوية مختلفة.

باستخدام برمجيات الحاسب الآلى المعتمدة للنمذجة والمحاكاه، تمت محاكاة استهلاك الطاقة لحالة أساسية لمبنى سكنى مكيف مكون من طابقين ذو كتلة مربعة تواجه أضلاعها الاتجاهات الأصلية، وتم مقارنة النتائج مع نتائج كتل ذات تشكيلات أخرى تشمل مستطيلات بنسب استطالة متعددة ومبنى على شكل حرف U وآخر H ومربع ذو فناء داخلى. تمت المحاكاة لجميع الأشكال فى التوجيهات المختلفة ذلك لمدن القاهرة والإسكندرية بمصر وجدة بالمملكة العربية السعودية.

أظهرت النتائج أن الأشكال المتعارف عليها لعمارة الصحراء قد لا تؤدى دائما إلى النتائج المتوقعة منها من تقليل لاستهلاك الطاقة فى حالة كون المبانى مكيفة. ففى مدينة جدة على سبيل المثال، المبنى المربع غير المعزول ذو الفناء الداخلى نتج عنه زيادة 15% فى استهلاك الطاقة مقارنة بالمبنى المربع المصمت غير المعزول، بينما حقق 17% وفرا فى الطاقة عندما تم عزل حوائطه وهذا أكثر وفرا مما حققه المربع المصمت المعزولة حوائطه. وفى الإسكندرية ظهر هذا التأثير إلى حد أقل، فالمربع ذو الفناء غير المعزول نتج عنه زيادة 5% فقط عن المربع المصمت، بينما حقق 19% فرا عند عزل حوائطه ليكون من أكثر الأشكال كفاءة فى استهلاك الطاقة.

أظهرت النتائج أن استخدام العزل الحرارى يغير من ترتيب أشكال كتل المبنى المختلفة من حيث استهلاك الطاقة و أنه فى معظم الحالات أكثر تأثيرا من التوجيه، كما أظهرت اختلافا بين نتائج الاستهلاك فى المدن الصحراوية المختلفة.

وبهدف المقارنة بمدينة ذات مناخ مختلف عن المدن الصحراوية، تمت الدراسة أيضا لمدينة برلين بألمانيا.

1 Introduction

Passive techniques have been commonly used to mitigate the effect of the local climate and to improve comfort inside buildings located in desert environments. Design of the building form, selecting the appropriate orientation and using thermal insulation were issues of importance in passive architecture.

Nowadays, an increasing number of desert buildings are air-conditioned. It seems intuitive to use passive techniques to minimize energy consumption. However, the performance of these techniques in case of air-conditioned buildings is questionable and requires careful examination. For example, the self-shaded naturally ventilated courtyard buildings are typically recommended for desert environments, while the increase in the exposed surface area of a building is typically not recommended in desert climates as the building will be more subjected to outdoor conditions and more liable to heat transfer between the indoor and the outdoor. In this case, a careful investigation is needed as natural ventilation is not a key issue in air-conditioned courtyard buildings.

As such, a number of research questions are raised:

What is the energy-efficiency ranking of building forms located in desert environments? Which is of more effect on the energy performance: building form, orientation or thermal insulation? How much is that effect? Does the same effect apply to all desert cities? Can thermal insulation eliminate the negative effect of the increased surface area? Does thermal insulation have the same effect on all forms in a certain city? Can it change the rank of building forms if ordered according to energy-efficiency?

All these questions reflect the need for evaluating the validity of the commonly known assumptions and for quantifying the effects of building form, orientation and thermal insulation as passive techniques when applied in air-conditioned buildings located in desert climates.
Literature showed that the effect of building form as a passive strategy was discussed in numerous research work:

The effect of building form on energy consumption was addressed by Depecker et al. [1] in which the energy consumed for heating was related to the building form through a shape coefficient that related external surface area to the inner volume. It showed to be more applicable to cold climates with medium or short periods of sunshine. Oral et al. [2] addressed the limit values of heat transfer coefficient with respect to external surface area-to-volume ratio of building forms aiming at minimizing heat loss in cold climates.

Okeil A. [3] proposed a multi-storey residential building form derived by cutting solar profiles in a conventional block that aimed to maximize the potential of passive utilization of solar energy by maximizing solar energy falling on facades while minimizing that falling on roofs and on the ground surrounding buildings in an urban area in winter. The building was studied for latitude 48o, where solar exposure was the main issue, which might not apply to hot desert climates. Hachem et al. [4, 5] studied the effect of a number of geometric forms and clustering alternatives on the solar potential of housing units. Kämpf and Robinson [6], and Kämpf et al. [7] performed an optimization process for the building and urban geometric forms to maximize the utilization of solar irradiation incident on the building envelope. Ratti et al. [8] studied the effect of building form on the environmental performance on the urban scale addressing shadow density and daylight distribution in street.

Courtyard building forms were examined in numerous studies. The shading performance of different polygonal courtyard forms was examined by Muhaisen and Gadi, [9]. The effect of courtyard proportions on solar heat gain and consequently on cooling and heating energy requirements was studied in the temperate climate of Rome using solid forms with no external windows [10]. It was found that the geometrical shape of the courtyard had a very small effect on shading in winter in comparison with summer; and courtyards with deep proportions were recommended over shallow ones. However, in both studies the tested buildings were solid with no windows, and thus both the effect of transmitted solar radiation and the energy needed for artificial lighting were not considered.

The effect of a naturally ventilated courtyard on thermal performance was studied in hot arid, tropical and warm humid tropical climates [11, 12, 13]. In these publications, the effect of courtyard presence, ventilation in daytime and/or night-time, presence of a water pool as well as courtyard shading was addressed. Results indicated that a courtyard building with controlled natural ventilation, of specified opening time, type of ventilation and position of openings improved thermal performance. However in the hot arid climate, the thermal performance resulting from continuous day and night natural ventilation was worse than keeping the building closed without natural ventilation [11].

Safarzadeh and Bahadori studied the passive effect of courtyard use on energy consumed for heating and cooling, including the effect of shading, planting and water pool [14]. It was found that these passive features alone could not maintain comfort during the hot summer times in the city of Tehran, Iran and that similar effects could be obtained through thermal insulation of walls and roof, double glazing, use of Persian blinds and infiltration-reduction. However, the energy needed for artificial lighting that compensates for the effect of shading was not accounted for.

The effect of building orientation on thermal performance was addressed by Al-Tamimi et al. [15] for non-air-conditioned buildings in hot-humid climate while Morissey et al. [16] studied the implications of orientation on thermal energy efficiency in Melbourne, Australia.

Literature showed that the quantitative analysis for the impact of building forms, orientation, and passive treatments such as thermal insulation in case of two-storey residential air-conditioned buildings located in desert environments are not sufficiently addressed and needs more investigation.

2 Objectives

This research aims to quantify, evaluate and compare the effect of building form, orientation and wall thermal insulation - as passive techniques - on energy consumption of air-conditioned two-storey residential buildings located in different desert climates.

3 Methodology

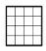
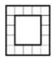
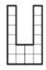
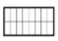
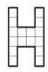
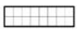
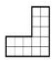
To evaluate the effect of building form and orientation, eight building forms were tested. Rectangular forms of proportions 1:1 (square), 1:1.5, 1:2 and 1:4, in addition to a square courtyard building, and U, H and L-shaped buildings were modelled and simulated for energy performance.

The solid square building was used as a base case. Analysis was performed by comparing the energy consumption of the tested building forms to that of the base case. Percentage of change in consumption was calculated and compared accordingly.

The building forms were tested in eight orientations. As the square building was symmetric about its axes, only the N and NE orientations were displayed representing the eight orientations. The same was done for all forms.

To evaluate the effect of wall thermal insulation, a layer of 5cm insulation was added to the walls. Then, these wall-insulated buildings were simulated for energy performance and compared to the base case. Table 1 shows the tested building forms.

Table (1) Simulated cases of building forms

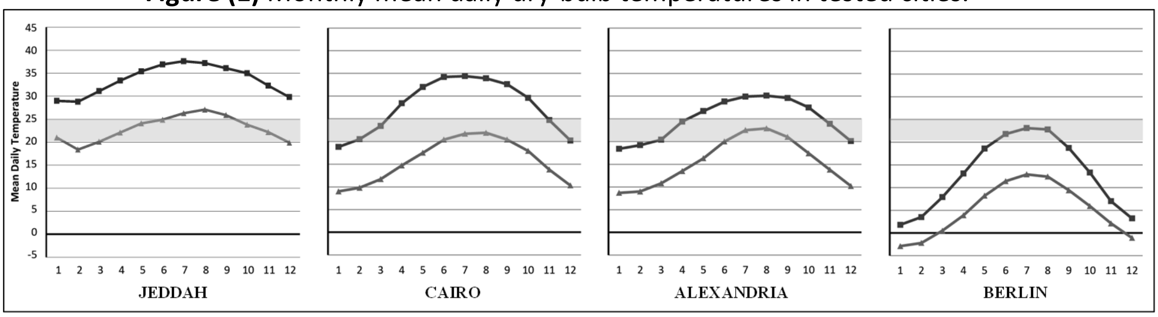
BUILDING FORM CASES											
CASE			Form Type	Form Proportions	Perimeter	CASE			Form Type	Form Proportions	Perimeter
Case (1)			Square	1:1	64m	Case (5)			Square Courtyard	1:1	128m
Case (2)			Rectangle	1:1.5	65.3m	Case (6)			U-Shape	-	112m
Case (3)			Rectangle	1:2	67.8m	Case (7)			H-Shape	-	112m
Case (4)			Rectangle	1:4	80m	Case (8)			L-Shape	-	80m

The alternatives were modelled using the Design Builder software and simulated for energy performance using the Energy Plus. Loads for both the HVAC and artificial lighting systems were considered.

Energy simulation was performed for three desert cities: Jeddah (Saudi Arabia), Cairo (Egypt) and Alexandria (Egypt). They were classified as hot-arid desert according to Köppen-Geiger climate classification [12]. However, there are differences between the three cities in regards to temperature ranges despite being of the same classification. For comparison purpose, simulations were also performed for a city of a temperate climate; Berlin, that was classified as a warm temperate city with fully humid warm summer [12].

Temperature is generally higher in Jeddah than all other cities all year round, even in winter time where it reaches about 30^{o}C. Cairo maximum temperature is generally higher than that of Alexandria, especially in summer, Figure 1.

Figure (1) Monthly mean daily dry-bulb temperatures in tested cities.



By comparison, temperature ranges in Berlin are generally colder than the other cities. The maximum temperature in Berlin is nearly similar to the minimum values in Cairo and Alexandria, especially in summer.

4 Parameters

A two-storey residential building of 256m^2/floor area was modelled. It represents a typical single family house in Saudi Arabia. It could also represent a single high-end family residence or a several family dwelling in Egypt. The building size was selected to fit common new residential land lots in Egypt and Saudi Arabia. They usually range from 500 to 600m^2, while building regulations usually specify a maximum allowable built area of 50% of land area, resulting in a 250m^2 floor area.

Table (2) Simulation parameters for tested building forms.

SIMULATION PARAMETERS									
BUILDING				**HVAC**	Setpoint	setback	**LIGHTING**		
Area/floor	256 m2	No. of people	7	Cooling	23	28	Type	Fluorescent	Suspended
Total Area	512 m2	Ground floor	Living	Heating	22	12	Daylighting control		
No. of zones/floor	16	First floor	Bedroom	Type	Split		illuminance: 200 lux	Dimming: On/off	Sensor Height: 0.8m
CONSTRUCTION									
External walls	20cm concrete block + 2cm cement plaster each side								
External walls (Insualted)	2 layers of 10cm concrete block + 5 cm polystyrene foam in the middle + 2cm cement plaster each side								
Internal walls	10cm concrete block + 2cm cement plaster each side								
Roof	Insulated with 10 cm polystyrene foam								
Internal slab	20cm concrete + 10cm flooring + 2cm plaster								
Windows	Area	"Square" WWR 20% fixed for all forms					Type	Double-glazed clear	

In the modelling process, buildings were hypothetically divided into 16 zones/floor, each of 16m^2 in area. The floor height was assumed to be 3m. Total window area was fixed for all forms. It was calculated to provide 20% window- to-wall ratio (WWR) of the 'square' case. Simulation parameters are shown in Table 2.

5 Results and Discussion

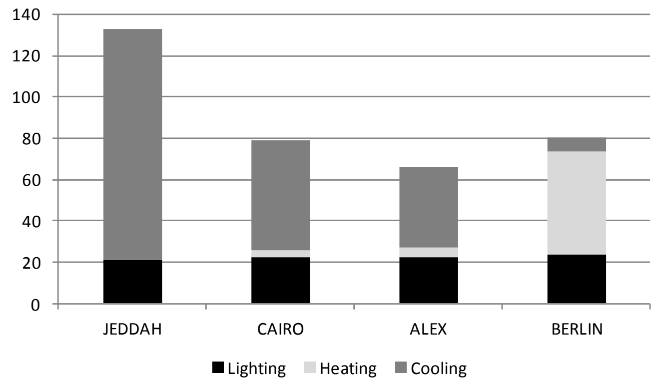
Simulation results reflected the impact of climate conditions on energy consumption across the tested cities. Results came as follows:

Base Case results:

Base case results, Figure 2, showed that energy consumption was highest in Jeddah. Energy use intensity (EUI) reached 133 Kwhr/m^2 per year, highly dominated by cooling loads of 112 Kwhr/m^2, no heating loads and 21 Kwhr/m^2 lighting loads. Cairo and Berlin were of a nearly similar annual EUI of 79 and 80 Kwhr/m^2 respectively, but with a difference in loads distribution; Cairo was cooling dominated with small heating loads of only 3 Kwhr/m^2, while on the other hand, the heating loads were dominant in Berlin where cooling loads did not exceed 7 Kwhr/m^2 only. The EUI of

the base case in Alexandria was the minimum, and reached 66 Kwhr/m^2 dominated by cooling loads.
Lighting loads of the base case were of small differences across cities, where the consumption was 21, 22, 23 and 24 Kwhr/m^2 in Jeddah, Cairo, Alexandria and Berlin respectively, However, it reflected the increase in need for artificial lighting in cities of higher latitudes.

Figure (2) Energy use intensity of base case across tested cities.



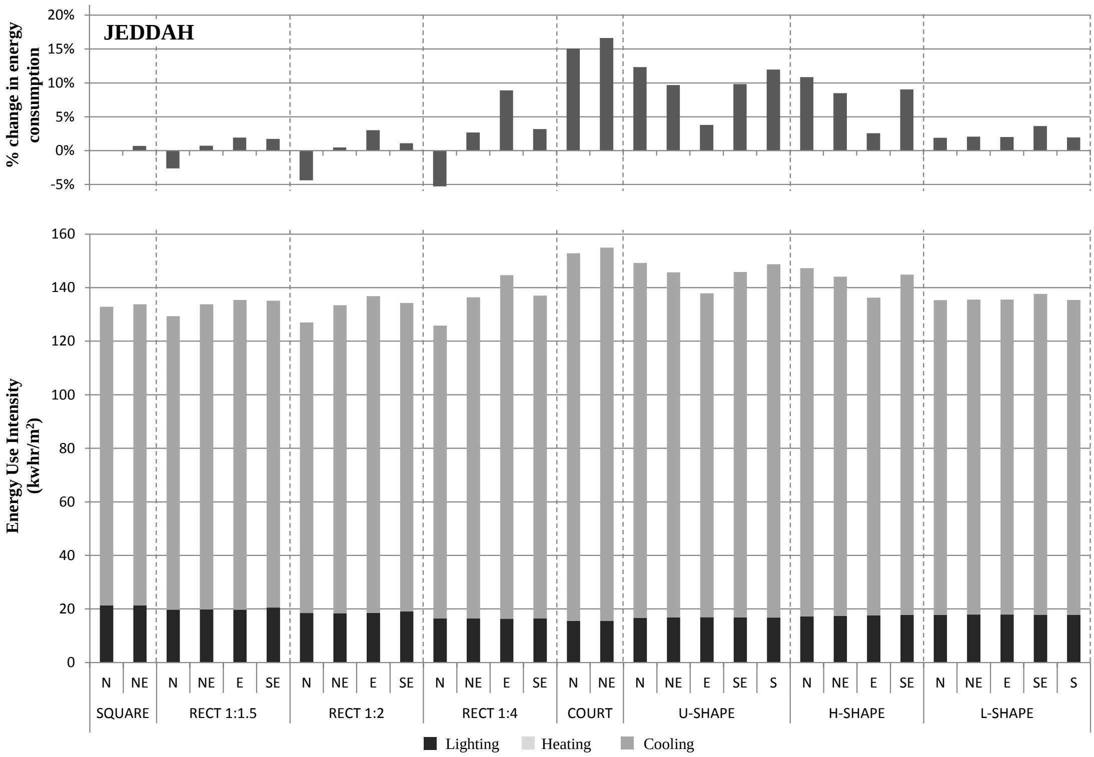
Effect of Form and Orientation:

Results of tested building forms differed according to orientation. Forms consumed minimum energy when their longer sides were facing north and south, while consumed highest energy when the longer sides faced east and west. Values of energy consumption in secondary orientations (NE, SE, SW and NW) were between those of the former orientations. Forms having sides of length proportions 1:1 (solid square, and square with courtyard) consumed less energy when faced the principal orientations, while a small increase occurred when faced secondary orientations. The amount of change in energy consumption due to orientation differed according to the form and city.
Forms of higher difference in proportions – such as Rectangle 1:4 – were more sensitive to change in orientation, as the amount of solar radiation received by the building envelope decreased significantly when the long façade faces the north. In forms where change in orientation did not result in a significant change in the surface area of façade subjected to solar radiation – such as square, courtyard and L-shape – the change in consumption due to orientation was not significant. In Jeddah, Cairo and Alexandria, the change in orientation had a significant effect, while the effect was very small in the temperate climate of Berlin.

In Jeddah, Figure 3, results showed that all forms were higher in consumption than the base case, expect for rectangular cases that achieved savings only when oriented to north. In this orientation, the rectangle 1:4 was the most efficient tested form as it achieved savings of about 5%, followed by rectangle 1:2 (4.3%) and rectangle 1:1.5 (2.6%). They were followed by the north-oriented square base case, then by the L-shape that lead to an increase of 2% to 3.6% according to orientation. The H-shape increased consumption by a range 2.6% to 10.8%, while the U-shape was higher by a range of 3.8% to 12.3%.

The form of highest energy consumption was the courtyard building that lead to an increase of 15% and 16.6% when oriented to principal and secondary orientations respectively. This can be explained as the courtyard building was the form of the largest surface area, and thus, the most exposed outdoor conditions.

Figure (3) Energy use intensity of forms with walls un-insulated in Jeddah and percentage of change in energy consumption compared to the base case.



From these results it was evident that forms were more efficient when they faced the north by the longer façade, and thus less subjected to direct solar radiation. Their highest consumption was in the case where longer facades were oriented to east and west. The H and U-shapes consumed less energy when oriented to the east, as with their east/west longer axis, their longer facade faced the north, Table1.

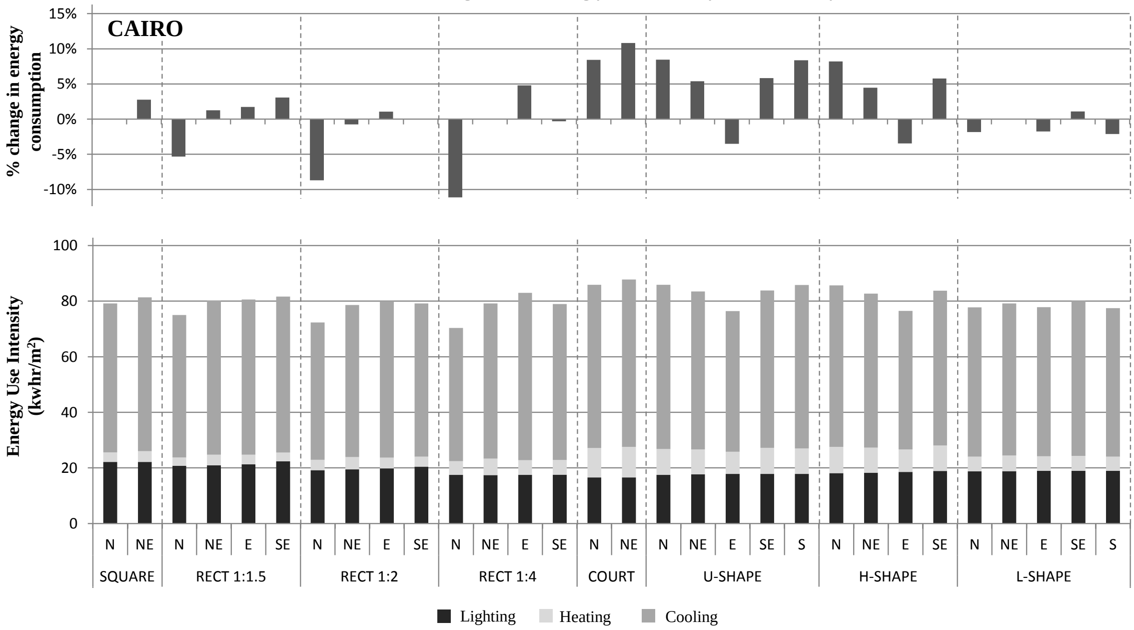
When oriented to secondary directions, consumption values came intermediate between those of principal orientations for forms of non-symmetric proportions (rectangle cases and U and H-shapes), while a small increase occurred in forms of symmetric proportions (square, courtyard building and L-shape), as in the latter ones the secondary orientation lead more surface area to be subjected to direct solar radiation.

Comparison of forms showed that the east oriented U and H-shapes, were of close values to the SE-oriented L-shape, east oriented rectangle 1:2 and to the NE and SE-oriented rectangle 1:4, while were much more efficient than the latter when oriented to east.

Cairo and Alexandria showed a similarity in the order of forms according to energy consumption with some differences in values of percentage of change from the base case.

In Cairo, Figure 4, the rectangle cases achieved savings when oriented to north, like in Jeddah. The percentage of savings reached 11.1%, 8.7% and 5.3% for the rectangles 1:4, 1:2 and 1:1.5 respectively. These percentages were nearly double those recorded in Jeddah, however, the absolute values of energy consumption in Cairo were still much less their corresponding values in Jeddah. Unlike Jeddah, the U and H-shapes in Cairo achieved savings. This occurred when oriented to east and reached about 3.5%. In orientations other than east, the U and H- shapes increased consumption by about 5-8% and 4-8% for both forms respectively. The courtyard building was the highest in consumption as it lead to an increase of 8.4% to 10.8%. However, these percentages were much less than the corresponding ones in Jeddah. The L-shape was very close results to the base case, with minor changes in consumption in all orientations.

Figure (4) Energy use intensity of forms with walls un-insulated in Cairo and percentage of change in energy consumption compared to the base case.

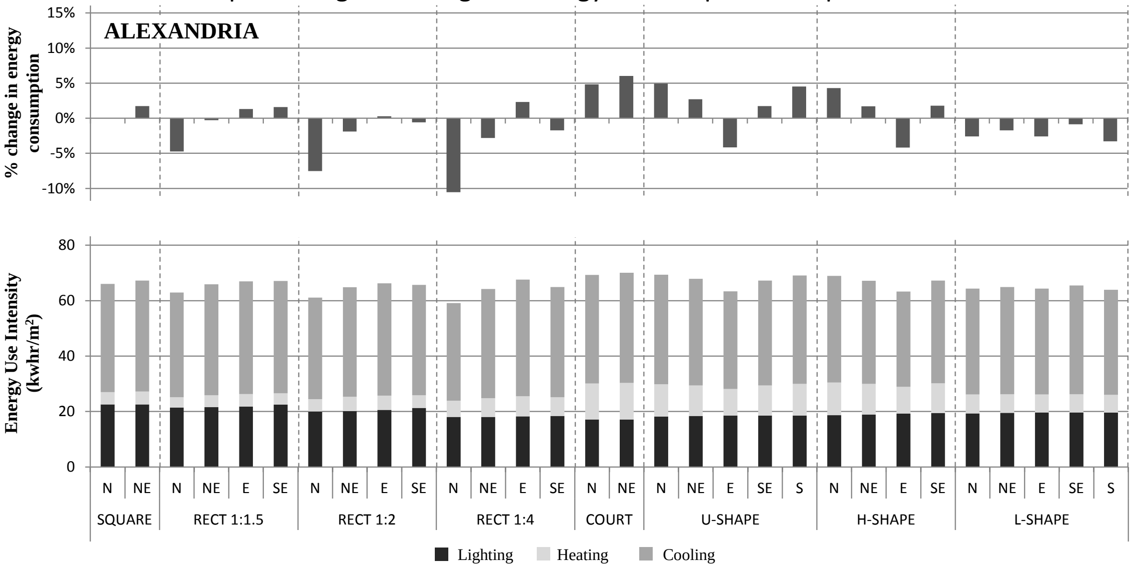


Results in Cairo also showed that the rectangle 1:2 oriented to NE, E and SE, and the rectangle 1:4 oriented to NE and SE were of nearly the same energy performance as the base case with minor savings or insignificant losses. These forms in these orientations in addition to the rectangle 1:1.5 oriented to NE, E and SE were more efficient than U and H-shapes except when the latter ones were east-oriented.

In Alexandria, Figure 5, the hierarchy of forms was the same as that in Cairo, but due to its moderate climate, the forms of large surface area, such as the courtyard building and the U and H-shapes, did not lead to a large increase in consumption as occurred in Cairo or Jeddah. For example, the NE-oriented courtyard building did not exceed 6% increase in consumption, while the U and H-shapes did not exceed 5%

when oriented to north. This can be explained as the moderate outdoor temperature resulted in a smaller temperature difference between indoor and outdoor and thus a less heat transfer by conduction though the building envelope, which in turn made the issue of surface area of a smaller effect in Alexandria than in Jeddah and Cairo.

Figure (5) Energy use intensity of forms with walls un-insulated in Alexandria and percentage of change in energy consumption compared to the base case.

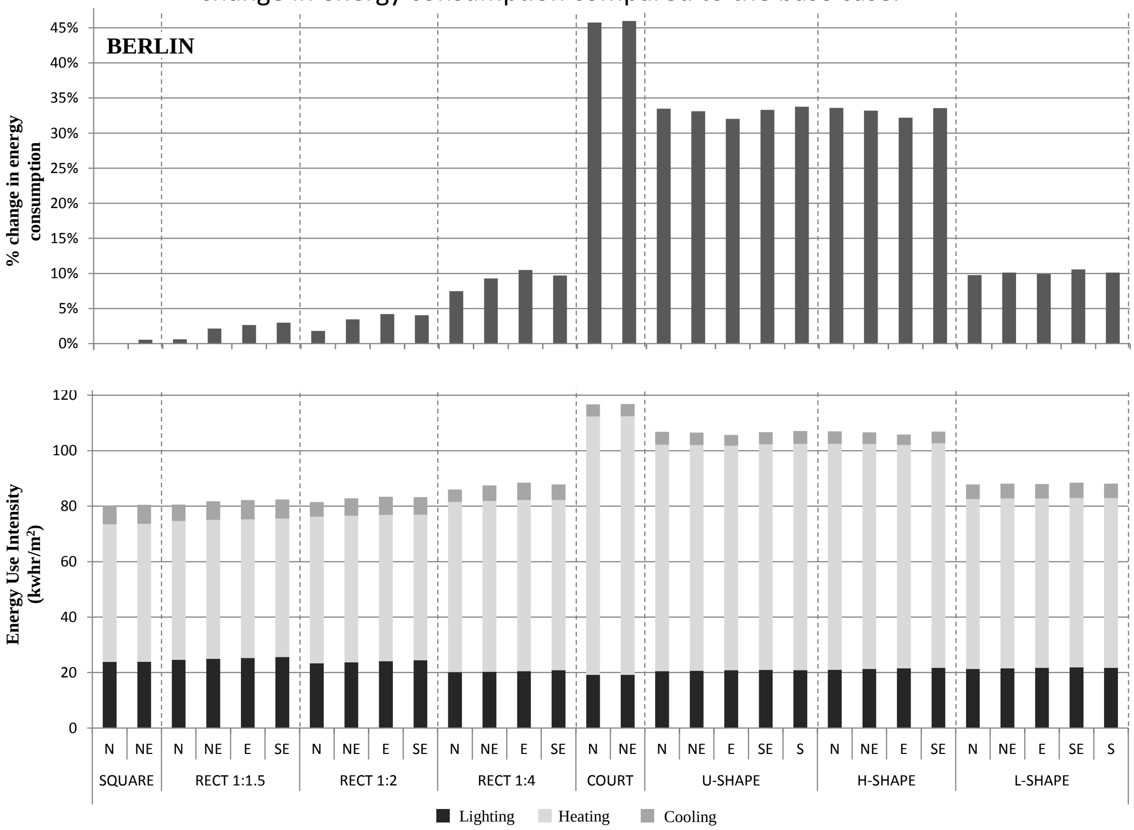


By ranking the most efficient orientation of tested forms, the north-oriented rectangles 1:4, 1:2 and 1:1.5 showed savings of 10.5%, 7.5% and 4.7% respectively, followed by east-oriented U and H-shapes (4.1%) then the L-shape (3.2%), followed by the square then by the north-oriented courtyard building that was 4.8% higher than the base case.

In Berlin, results we significantly different than desert cities. The most efficient form was the square, followed by the rectangles 1:1.5, 1:2, 1:4 respectively then the L-shape, then both the U and H-shapes then by the courtyard building. The difference in consumption between forms reached more than 45%, which was significantly larger than in all other tested cities, Figure 6.

It was clear that the efficiency of building forms was directly proportional to surface area of the building envelope. Unlike desert cities, solar radiation in Berlin was not the major factor, this lead the determining factor to be the difference in temperature between indoor and outdoor which in turn lead the surface area to be the determinant factor. For the same reason, the change in orientation was not significant.

Figure (6) Energy use intensity of forms with walls un-insulated in Berlin and percent of change in energy consumption compared to the base case.



As the square and rectangles 1:1.5 and 1:2 were of small differences in perimeter (64 to 67.8 m), their consumption were close with a difference of less that 5%. As the perimeter increased to 80m in cases of the rectangle 1:4 and the L-shape, their consumption were close to 10% higher than the square. By reaching 112m in cases of U and H-shapes, consumption was more than 30% higher than the square, while by reaching 128m the courtyard building was more than 45% higher than the square bases case.

Effect of Thermal Insulation

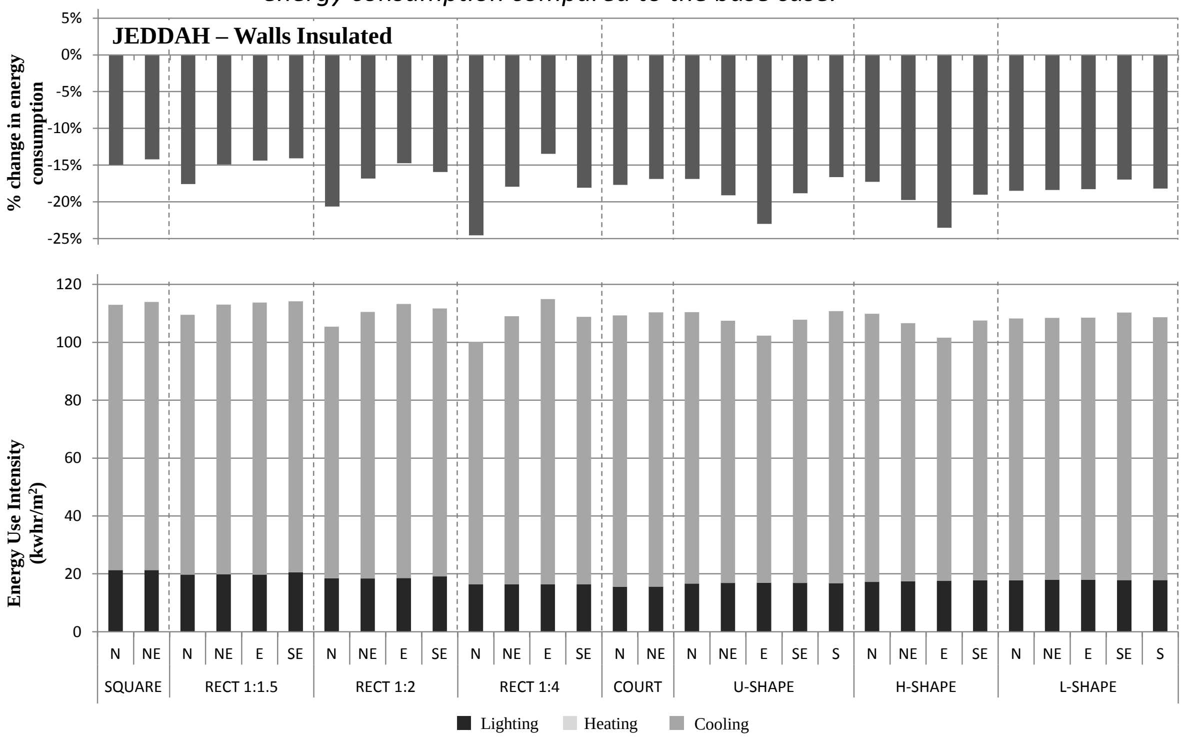
By adding a layer of insulation to the external walls, a substantial change occurred in results. All forms in all cities achieved savings compared to the base case. Performance of forms of large surface areas improved significantly. In some cases, these insulated forms were more efficient than the best performance un-insulated ones.

In Jeddah, Figure 7, all insulated forms highly exceeded the savings achieved by the most efficient un-insulated form that showed only 5% savings. The insulated square achieved 15% savings compared to the base case. The insulated north-oriented rectangle 1:4 along with the east-oriented H and U-shapes (longer facades facing north) were the best performing cases with savings ranging from 23-25% approximately.

The insulated courtyard building achieved 17.7% savings, indicating more than 32% improvement over its un-insulated case which was the highest energy consuming form. It also showed more savings than the insulated square and was of nearly the same performance as the north-oriented rectangle 1:1.5 and the L-shape, while resulted in less than 3% increase in consumption over the north-oriented rectangle 1:2. Also unlike the un-insulated case, the insulated courtyard was either of similar or better performance than all insulated rectangles in all orientations unless rectangles were oriented to north.

The difference in consumption between the best performing rectangle 1:4 and both the east-oriented H and U-shapes was less than 2% when insulated, while was 7.5-9% in the un-insulated case. The difference between the rectangle 1:4 and the courtyard was 6.7% when insulated while reached about 20% in the un-insulated case.

Figure (7) *Energy use intensity of wall-insulated forms in Jeddah and percent of change in energy consumption compared to the base case.*



This indicated that adding a layer of thermal insulation in external walls minimized the effect of building form on energy consumption and, moreover, it changed the hierarchy of forms when ordered according to energy consumption.

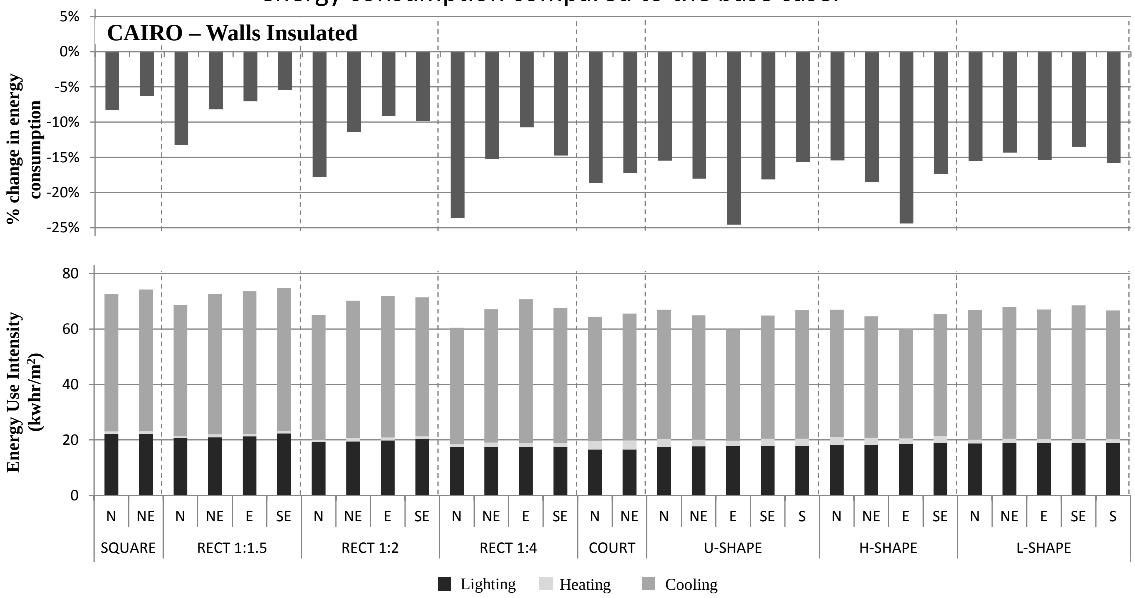
This can be explained as follows: the building forms differed in both surface area, the availability of daylight and possibility of self-shading. Forms of large surface area (courtyard building and U and H-shapes) had more potential for self-shading than other forms, which minimized the transmittance of direct solar radiation and thus decreased cooling loads. In the meantime, as all zones were daylit, they needed less artificial lighting, and thus decreased the heat emitted which in turn decreased the cooling loads. However these forms had larger surface areas than other forms (up to double that of the base case), which increased heat transfer by conduction across the envelope and significantly increased cooling loads. When insulated, this negative effect is minimized, while the positive effect was still retained. By this, forms of large surface areas had more potential to benefit from large savings due to insulation than ones with smaller surface areas, while keeping the benefits of daylighting and self-shading.

Insulation slightly dampened the effect of orientation. For example the difference between the North-oriented and East-oriented rectangle 1:4 was 14.1% in the un-insulated case, while was 11% when insulated.

In Cairo, Figure 8, the insulated square recorded one of the lowest savings in insulated forms (8.3%), while the east-oriented U and H-shapes were of the highest savings (24.5% approx.), to which the north-oriented rectangle 1:4 was of very close savings (23.6%). The courtyard achieved 18.6% savings, which was more savings than the L-shape, rectangles 1:1.5 and 1:2, and then the rectangle 1:4, U and H-shapes except when the latter forms faced the north by it longer facades.

Results in Cairo indicated a total change in the hierarchy of forms when ordered according to energy-efficiency, and that self-shading insulated forms of large surface areas recorded high performance.

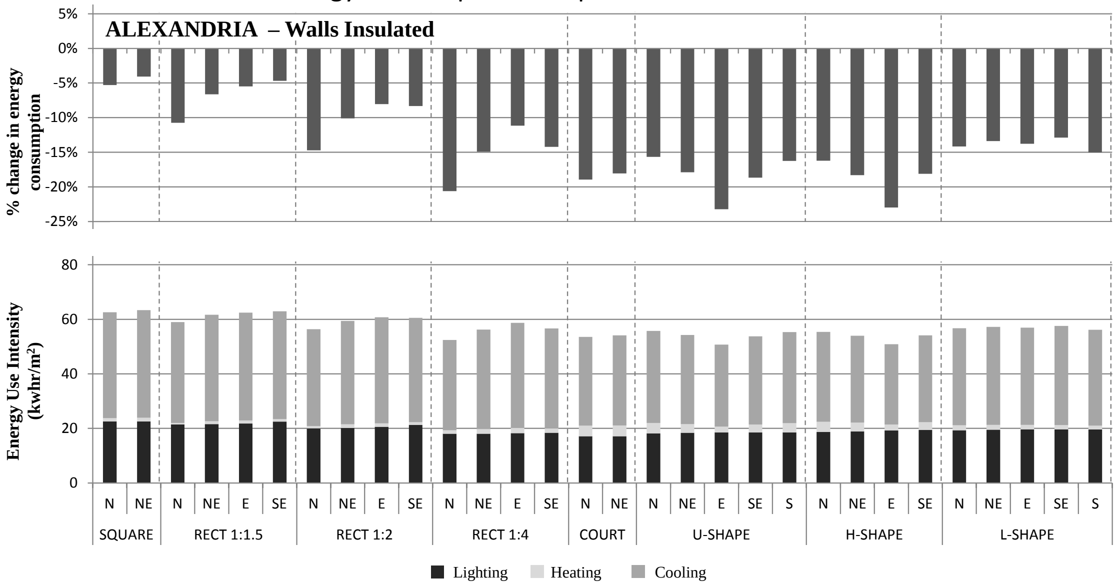
Figure (8) Energy use intensity of wall-insulated forms in Cairo and percent of change in energy consumption compared to the base case.



In Alexandria, Figure 9, results showed a similarity to that of Cairo. However, the insulated square recorded only 5.2% savings, while the east-oriented H and U-shapes were of the highest savings (23% approx.), showing 2.5% more savings than the rectangle 1:4. The courtyard building result was very close to the latter form with only 1.5% difference.

The results of both Cairo and Alexandria indicate that the courtyard building – despite being of the largest surface area - was of close results to the north-oriented rectangles 1:2 or 1:4, and moreover, it was more efficient than the rectangles if they faced other orientations. This showed that insulated courtyard buildings are more liable to be used in Cairo and Alexandria.

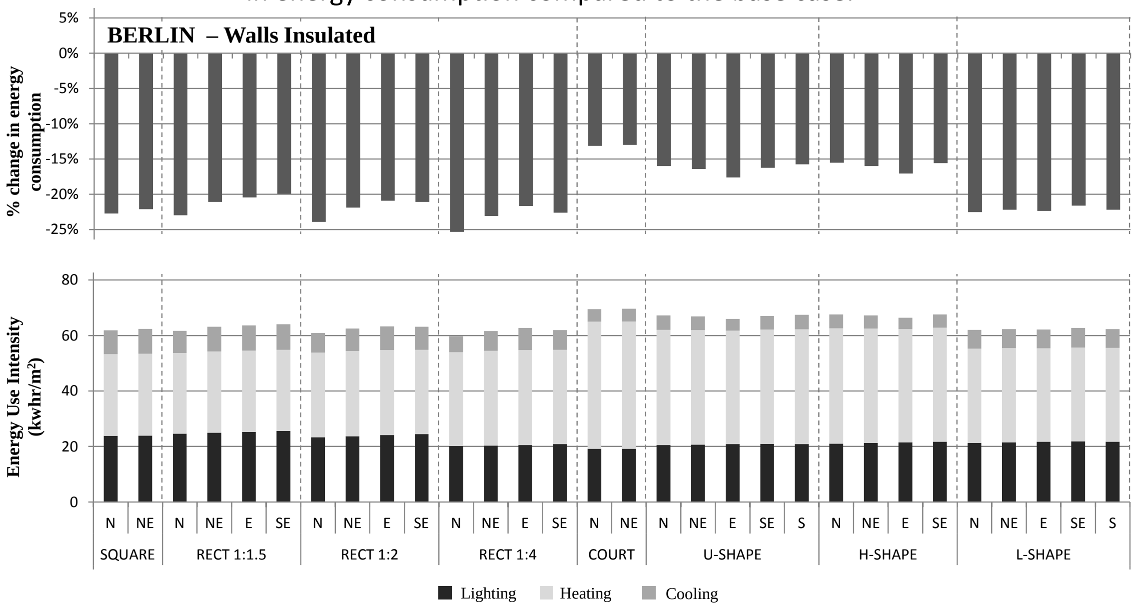
Figure (9) Energy use intensity of wall-insulated forms in Alexandria and percent of change in energy consumption compared to the base case.



In Berlin, Figure10, all insulated forms achieved large savings compared to the un-insulated base case, which was of the best performance within the un-insulated cases. Unlike desert cities, self-shading forms of large surface area were less in savings than exposed forms of small surface area. The courtyard building was the lowest in efficiency. This showed the high effect of heat transfer by conduction in this city - as it was clear in the un-insulated forms case - and in addition, it showed that self-shading in this city would lead to increase the overall energy consumption by increasing heating loads. The highest savings were achieved by the rectangles, square and L-shape cases that were of close values ranging from 20% to 25%.

Results of the insulated cases showed that thermal insulation significantly dampened the effect of building form in cities with extreme climates (Jeddah and Berlin), while in cities of mild climates (Cairo and Alexandria) the significance of form was still retained. This can be shown by comparing the range of difference in energy consumption between the form of the highest efficiency and that of lowest efficiency in each city, and of the same orientation (all with their long facades facing north). In Jeddah, this range was dampened from 20% in the un-insulated forms case to only 10% in the insulated one, while in Berlin, it was dampened from 45% to only 12.2%. On the other hand, in Cairo and Alexandria, only a minor change occurred in this range from 20% to 16% and from 15.3% to 18% for the two cities respectively, indicating that in mild cities, the effect of building form is of nearly the same significance, even when insulated.

Figure (10) Energy use intensity of wall-insulated forms in Berlin and percentage of change in energy consumption compared to the base case.



6 Conclusions

The effect of building form on energy consumption was determined by calculating the difference between the building forms of highest and lowest energy consumption in each city. It reached nearly 20% in Jeddah and Cairo, 15% in Alexandria, while reached 45% in Berlin. However, the effect of building form should not be separated from that of orientation as the latter was of high significance especially in desert cities.

Form and Orientation:

The order of building forms according to energy-efficiency varied across cities, while the best orientation of forms did not vary. The highest efficiency was obtained when the longer sides of a form were oriented to north and south, while the highest consumption occurred when they faced east and west. Intermediate orientations resulted in intermediate results. The longer the building form proportions (eg. Rectangle 1:4), the higher the effect of orientation.

In all tested desert cities, the north-oriented rectangle 1:4 was the most efficient form when oriented to north and south, followed by the rectangles 1:2 and 1:1.5, while the courtyard building was always the one of highest consumption. This indicated that the effect of surface area on energy consumption was higher compared to that of self-shading in the courtyard.

In the extreme hot climate of Jeddah, the U and H-shape forms – of large surface areas but less than the courtyard building - facing the north with their longer sides (best orientation) were of higher consumption than the square base case, while in the mild climate of Cairo and Alexandria, they were of lower consumption and thus more efficient. This indicated that the effect of exposed surface area is more significant in the hot climates than in mild climates. Results of courtyard building, U and H-shapes showed a more liability to be used in mild climates than in extreme hot ones.

In desert cities, the energy was consumed mainly for cooling and lighting, while heating energy was very small. The contrary was in Berlin. The order of forms in Berlin was directly proportional to the surface area of the form, while the effect of orientation was insignificant.

Insulation:

By adding a layer of 5cm thermal insulation, the performance of all forms improved significantly. All forms achieved savings compared to the base case in all cities. Forms of large surface areas were of the highest benefit. The insulated courtyard building in Jeddah achieved 32% improvement over the un-insulated case. As a larger decrease occurred in forms of larger surface areas, the order of forms according to energy efficiency changed. The smallest improvement occurred in the square building of the smallest surface area.

In Jeddah, the rectangle 1:4, U and H-shaped forms were of close values and were of highest efficiency followed by the rectangle 1:2. The courtyard building, L-shape and rectangle 1:1.5 were of close values that were of better performance than the square. The difference between the rectangle 1:4 and the courtyard building decreased to 6.7% when insulated, instead of 20% in the un-insulated case. In Cairo and Alexandria, the U and H-shapes exceeded the savings of the rectangle 1:4 and were of highest efficiency, and the three of them were directly followed by the courtyard building. In Berlin, the differences between forms were dampened by insulation. The forms of large surface area were of higher consumption than those smaller ones that were nearly of close energy consumption values.

In general, the effect of adding a layer of thermal insulation to external walls on energy consumption was higher than that of building form and orientation in all cities.

7 Limitations

The tested forms were limited to the 256m^2 floor area, as described above. This resulted in rather 'thin' forms in some of the tested cases such as in U, H and courtyard forms. In these cases, several zones were exposed to the outdoor environment from two or three sides. If the building area was larger, fewer zones would be exposed from multiple sides, possibly resulting in a different performance. This aspect could be addressed in a future study.

Acknowledgements

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THE GOVERNANCE OF RESILIENT SOCIETIES
The Case of Cairo Informalities

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Abstract

The undergoing processes of formalization of the informal city in Cairo present a change in paradigms. This requires a deep understanding of all the actors involved, starting from the policy makers, to the city residents, and identifying the role of urban planners, theorists, and practitioners, within that changing urban order. This paper attempts to highlight the governmental approaches dealing with the informal sector, in relation to the formalization initiatives that is currently practiced on ground, by the informal city inhabitants. Addressing and questioning the role of the urban planner, within the discourses of theory and practice, in dealing with the formal and informal cities, that are continuously changing the city landscape. Applied research has shown that when the poor realize that investments in the built environment benefit them directly, they are willing to pay. The more value-for-cost, the more they pay. Once again, the informal areas hold lessons for policy makers in this regard. Unfortunately, the huge investments that residents are making is not recognized as a potential source of income by the government, and there is still a lack of interest in understanding when and why residents of informal areas are willing to invest in their residential environments.

The state's seeming inability to clear potentially threatening informal areas on a large scale reflects not simply an absence of material capacity or the bottom-up resistance of their inhabitants but also constraints embedded in the political order and its logic of top-down rule. This suggests that any comprehensive approach to urban informality requires giving such neighbourhoods a measure of legal recognition and allowing them to develop a measure of social autonomy (Dorman, 2009). These processes have to be studied in relation to the governmental approaches to deal with the informal sector. The governance of these resilient societies needs to be rethought with the contemporary changes providing innovative solutions that engage community participation.

الملخص

يواجه العمران غير الرسمي في الوقت الحالي تحديات كبيرة أدت إلى تطور سكانه ليصبحوا مجتمع مرن. وفي ظل المحاولات المستمرة لإضفاء الصبغة الرسمية على هذا العمران والذي يمثل قاطنيه على اقل تقدير نصف المجتمع القاهري تظهر العديد من التساؤلات حول الصور المختلفة التي مارستها وتمارسها الدولة في التعامل مع هذا العمران. فنحن الآن امام ظاهرة تستوجب تغيرا في الأطر الفكرية الحاكمة وفهم عميق لأدوار الجهات المعنية بدءا من صانعي السياسات حتى ساكني المدينة وتحديد دور مخططي المدن والمنظرين والممارسين ضمن هذه المنظومة. تحاول هذه الورقة القاء الضوء على المناهج الحكومية التي تتعامل مع القطاع غير الرسمي، فيما يتعلق بالمبادرات التي تمارس حاليا على الأرض والتساؤل حول دور التخطيط الحضري، ضمن الخطابات الرسمية والممارسة، في التعامل مع المدن الرسمية وغير الرسمية، التي تغير باستمرار مشهد المدينة، وبناءً على ذلك طرق حكم هذه المجتمعات المرنة وإعادة النظر في التغيرات المعاصرة للوصول لحلول مبتكرة تتضمن المشاركة المجتمعية.

Introduction

Understanding the governmental approaches that deal with the informal city is essential to understand the reasons beyond the current relationships between the formal and the informal cities as well as the future of these relationships. The government presented in the planners and the policy makers have changed their approach towards the informal sector of the city, several times. Starting from complete negligence, as if they never existed, to marginalization and stigmatization, which lead to proposing the demolition of all the informal settlements. However, this strategy proved to be a failure, so the government started to develop an approach of controlling the growth and sprawl of the informal city, through *tahzim* (belting and containment) strategy. Each of these approaches have affected the relationship between the formal and the informal cities and deepened the gaps and borders between their inhabitants. This part of the paper attempts to summarize the changes in policies and approaches towards the informal city, as well as the proposed futuristic approaches presented in Cairo 2050 report, and how realistic and applicable these approaches are?

2 The Government Approach

As has been repeatedly acknowledged, the phenomenon of informal areas is closely tied to the lack of an effective housing and urban development policy in Egypt. Although centralized decision making and the imbalanced distribution of resources across regions are improving, a housing and urban development strategy for Egypt still takes the form of a series of projects, implemented but not monitored and evaluated so as to provide a strong basis for successful policies. Numerous New Towns in the desert were planned and implemented during the 1970s to accommodate the increasing urban population and to protect the Nile Valley from overcrowding to prevent loss of fertile agriculture land. These cities did not attain their target population despite the continuous efforts of the government. The problem is multi-faceted. First, there is the tendency of the government to tie the success of the New Towns to political agendas, which leads to a repeated denial of their failure. Another mistake has been to insist on following divisive master planning principles, which have been shown to be unsustainable and do not yield liveable places in aspects such as safety, convenience, and community building. Very little time has been spent understanding how urban life and urban systems work, and the focus have been solely on speedy implementation and the meeting of political agendas. Instead of providing land for people to build on under zoning regulations that ensure sustainable and adequately serviced extensions of cities and new communities, the government has taken it upon itself to provide a fully developed 'product' that residents should not change or develop further. The idea of government as provider of housing came after World War II to solve certain pressing problems, but has been challenged over the decades, being substituted since the 1980s with the government in the role of enabler or facilitator.

Yet, the government still insist on building neighbourhoods that are inconvenient, wasteful, and unsustainable. One reason is that they look good on paper, with neatly-delineated shapes and separated colour codes. They are easy for politicians to understand, and easy for contractors to implement. Such recipes, easy for consulting firms to produce and reproduce, save time and money, since more complex designs would require multi-disciplinary teams and a participatory process with local authorities and user-representative groups. The norm is that the demand directs the characteristics of the supply. In housing, this means that the location, dwelling size, and neighbourhood design are shaped by what people need most, accommodating variety in household size, priorities, and lifestyles. Research shows that in existing city districts, and surprisingly enough in informal areas, the housing supply does reflect this variety in the demand. Filling entire neighbourhoods and districts with thousands of apartments, all of which have the same design, is not realistic. Clusters around undefined spaces are too expensive to landscape or maintain.

The Logic of Negligence

The Egyptian state's negligent governance of Cairo thus cannot be entirely the result of insufficient resources. The authoritarian and patrimonial character of the contemporary political order. While Egypt's rulers have considerable powers to act without bottom-up consent, their capacity to penetrate and mobilize Egyptian society is consequently circumscribed. For example, the absence of democratic bargaining contributes to state-society disengagement and limits the possibility of social regulation. The exigencies of regime reproduction, clientelism, and top-down distribution have exhausted state capacities. Finally, the state's tendency to risk avoidance may well stem from the denial of formal representation and participation, at least by peaceful means, to the people. In general terms, therefore, the Egyptian state can be seen as a "lame leviathan," appearing "both as domineering and authoritarian and as ineffective, rickety, and porous," with one observer going so far as to assert that it really controls only the "main axes" of the country (Munro, 1998; Rousillon, 1998)

This is manifest throughout informal Cairo. Given the scarcity of land available for officially sanctioned development, access to formal housing historically has been an important spoil in the clientilistic politics through which Egypt is ruled (Harik, 1997). Increasingly priced out of the formal private market since the 1970s, the people also have had little access to public housing. This consists of relatively small numbers of finished apartment blocks, the construction of which has been highly, subsidized, with access depending on clientilist connections (Hassan, 1985; Taher, 1986). Not surprisingly, many Cairenes in search of housing have entered the informal housing sector despite the absence of state recognition and the inadequacy of urban services (Bayat and Denis, 2000).

Neglectful rule also helps explain the durability of informal communities in the face of apparent official hostility. Given their preoccupation with direct challenges to their power, Egypt's rulers likely have had little capacity to police the seemingly peripheral zones of Egyptian society (Abt Associates with Dames and Moore and General Organization of Housing, Building and Planning Research, 1982). In some cases, state officials have found it profitable to turn a blind eye to informal urbanization (Fahmy, 2004). In others, they may tacitly have encouraged such settlements as a means of housing low-income Cairenes at minimal state expense (Tekce, Oldham, and Shorter, 1994). Such clientelism has not been purely a top-down phenomenon. Informal communities have often been able –via such clientelist mechanisms as intermediary notables or "relatives and friends located at different levels of the vast bureaucracy"- to gain gradual access to state services and avoid removal (Tekce, Oldham, and Shorter, 1994).

Demolishing the Informal City

In aggregate terms, however, the informal housing sector is highly resilient. As of 2000, approximately 82 per cent of the informal city had been developed on privately held agricultural land and 9 per cent had been built in state-owned desert areas (Sims, 2000). In the areas built on agricultural land, the state has tried merely to restrain further informal growth, with only limited effect (Sims, 2003).

As authoritarian governments allegedly are more likely to undertake urban redevelopment by means of demolition, the Egyptian state's relative tolerance of the Cairo informalities throughout the 1980s and 1990s needs to be explained (Hardoy and Satterthwaite, 1989). Two potential explanations, each of which has some of the qualities of a metanarrative, are immediately obvious. The first, is that of popular agency, bottom-up resistance, and subaltern protest, by which communities block state efforts to demolish them. There are numerous references in the secondary literature on Cairo, again necessarily anecdotal, to protracted struggles between the state authorities and informal homesteaders whose dogged persistence allowed them to outlast the police and resist removal. To quote from one account, set in the 1960s, of a squatter community in the industrial district of Helwan, some forty kilometres to the south of the city center, "The police used to come every day with a van wherever they found a hut they would call the bulldozer and knock it down. But the next morning they would come and find it rebuilt just as it was with people living in it. After four months the police stopped chasing us and destroying our houses" (El-Messiri, 1985)

In 1998, in Ard al-Liwa', the Zarayib area was threatened with removal to make way for access ramps connecting the Sixth of October satellite city road to the Cairo Ring Road. Again, members of the community sought outside assistance, in this case from a legal NGO, the Center for Human Rights Legal Aid. Coordinating the define of the community, was a loose network of community members and activists, some affiliated with the leftist Tagammu' Party, calling themselves the Popular Committee for the Defence of the People of Ard al-Liwa'. Their efforts to obstruct the clearance included organizing court challenges, mobilizing residents of the Zarayib neighborhood against the clearance; meeting with an activist who had secured compensation for another community threatened with demolition; publishing pamphlets setting out the injustices of the clearance; and seeking to generate sympathetic media coverage on behalf of the Zarayib community. Their efforts appear to have been successful, insofar as the community remained in place through 2001 (Dorman, 2009).

Bayat has described such struggles as "the quiet encroachment of the ordinary" and argued that they are "marked by quiet, largely atomized and prolonged mobilization with episodic collective action – open and fleeting struggles without clear leadership, ideology or structured organization" (Bayat, 2000). On the other hand, the role played by the NGOs, the 'Popular Committee for the Defence of the People of Ard al-Liwa', and the youth, is closer to that of a social movement in the minimal sense suggested by Charles Tilly: "A sustained series of interactions between power holders and persons successfully claiming to speak on behalf of a constituency lacking formal representation, in the course of which those persons make publicly visible demands for changes in the distribution or exercise of power, and back those demands with public demonstrations of support "(Tilly, 1984)

Whether in the form of quiet encroachment or a more vocal social movement, such popular agency can be seen as exerting a kind of continuous bottom-up pressure on the Egyptian state, constraining its discretion to intervene in Cairo… Egypt's rulers have long viewed Cairo principally as a security problem and vulnerable to "mass violence" that might bring it "and hence the nation to a halt" (Waterbury, 1982). As a result, they have practiced risk avoidance, eschewing evictions and demolitions that might galvanize the passive networks Bayat sees as underlying the Cairo "street," preferring to neglect the informal rather than coerce it (Dorman, 2009).

So, if the durability of informal communities is largely in the aggregate, then it must be explained in terms of similarly large-scale factors, rather than purely micro-level tactics. A second explanation for the lack of large scale clearances may be the Egyptian state's inability to construct a sufficient number of apartments to rehouse the tens of thousands, if not millions, of Cairenes who would be displaced. Hence urban-pocket areas, with relatively small numbers of inhabitants, are the most vulnerable to demolition. By contrast, when larger, more developed settlements, such as those on the agricultural fringe more generally, "gained a certain critical mass, there were simply too many families which required forced removal or which would require alternative (public) housing" (Sims, 2000).

This explanation suggests a different sort of metanarrative: that of a weak Egyptian state ruling an underdeveloped society (Ayubi, 1995; Waterbury 1985). Not only does the state have little capacity to intervene systematically in Egyptian society, from, which there are few resources to be had, but it is also itself a "major obstacle" to the society's " economic and social development" (Palmer, Ali, and el-Sayed, 1998). Critics have long decried the state's overcentraliztion, excessive red-tape, overstaffing, unskilled and apathetic employees, agencies with overlapping responsibilities, and poor internal coordination (Palmer, Ali, and el-Sayed 1988). In this context, the survival of the Cairo informal housing sector can be understood in terms of perennially impoverished state lacking the resources to intervene effectively in its capital. Although something of a cliché, this metanarrative has a measure of empirical plausibility. The expansion of informal Cairo, particularly of agricultural periphery communities, has often been understood in terms of the state's inability to accommodate Cairo's growth either by providing sufficient stocks of public housing or planned and serviced land suitable for formal urbanization (Harik 1997; Sims 2000; Steinberg 1990; Tekce, Oldham, and Shorter, 1994; World Bank, 1986)

The Futuristic Vision: Cairo 2050

Starting in 2008 the Egyptian government began spending considerable efforts to promote a future vision for Greater Cairo, with GOPP sponsoring a study called "Greater Cairo Strategic Planning 2050 Concept." Using a time horizon of over forty years, and some extremely optimistic assumptions about Egypt's demography and economic performance, government planners and their consultants have demonstrated in 'Cairo 2050' a continued penchant for the manufacture of unrealistic dreams. However, these dreams firmly reflect their wishes for Cairo to become a super-modern, high-tech, green, and connected city that can stand shoulder –to-shoulder with the metropolises in the world's most advanced countries (Sims, 2010).

Figure (1) Cairo 2050 vision of al-Haram street
Main street leading to the puramids platform, including the demolition of large areas of informal settlements

The features that collectively make up the 'Cairo 2050' vision are truly amazing, both in their daring and in their cost implications, There are to be new universities, libraries, movie studios, and specialized hospitals and museums, all of the highest international standards. There are also to be technology and research centres, new hotel and conference districts, immense new boulevards and architectural focal points. A prominent feature will be huge green areas and recreational parks, both in the city's desert and in what are now the historic cemeteries and Nile islands. Downtown Cairo will be huge green areas and recreational parks, both in the city's desert and in what are now the historic cemeteries and Nile islands. Downtown Cairo will be completely gentrified, and historic areas transformed into 'open-air museums.' Most government offices are to be relocated and concentrated into one large desert site. New central business parks are to be created on what are now poor neighbourhoods. Huge office towers and hotels will spring up all along the Nile. The informal and shabby parts of Cairo are either to be removed entirely (with the inhabitants relocated to public housing in the desert or to new neighbourhoods on agricultural land to be developed by private investors), or they are to be 'decongested' by creating wide roads and green corridors that cut through major informal areas. Millions upon millions of residents in informal areas will need resettlement. (Sims, 2010)

It hardly needs saying that few of the schemes and projects of Cairo 2050 will ever see the light of day. The colossal sums needed to finance investments will simply not materialize, and social resistance can be expected to be fierce. In a way it seems that government planners enjoy going through a rosy design exercise in which they can conveniently forget the reality that is present-day Cairo and over which the government has so little control. (Sims, 2010)

Cairo 2050 report envisions the future of Cairo by the year 2050. It presents a reading for the current situation of Egypt and Cairo in particular and proposes strategies for development. So this proposal has produced goals on the national scale through its capital Cairo. The goals that are defined for Cairo within a national vision of Egypt 2050 are; 1)Raising quality of life standards to become one of the best 30 countries around the world instead of the current ranking (84) of the 100 countries, 2)Raising human development standards to become one of the best 30 countries in the world instead of the current ranking (111) of the 180 countries.3) Raising quality of the Egyptian production, 4) Reaching higher rates in sustainable economic development (not less than 7.5% per year), 5)Achieving social equity (between different segments of society), 6) Restructuring the demographic distribution of Egypt, to enhance the benefit of Egypt's geographical location and its natural potentials, 7) Building an integrated society in which all can enjoy the rights of citizenship, and 8) Maximizing the effectiveness of Egypt's regional role on the Arab, Islamic, and African level.

Regarding the informal city, the vision categorized the informal settlements into two main sectors and consequently how to deal with them as follows:

First: Unsecure areas
Urban Areas unsecure for the life of its inhabitants or deteriorated areas: the strategy of rehabilitation could be compensate inhabitant or provide another adequate houses for them.

Second: Unplanned areas
Informal Areas with high density: needs decentralization, providing services and housing units; those housing units could be on the same area or near to it, according to each situation. Dealing with this areas through providing open accesses and roads,

essential services, facilities in pockets and vacant land, as well as job creation for the youth.

And in order to accommodate the increase in population growth the vision has provided a decentralization strategy for the redistribution of population in Cairo and Giza, through upgrading unsecure and unplanned areas by opening new access roads, providing suitable relocation areas (if needed) within the same governorate or in other governorates, preserving planned areas through enforcing building regulations; and dealing with non-planned areas through execution plans and precise time schedules.

Figure (2) Decentralization of Cairo centre

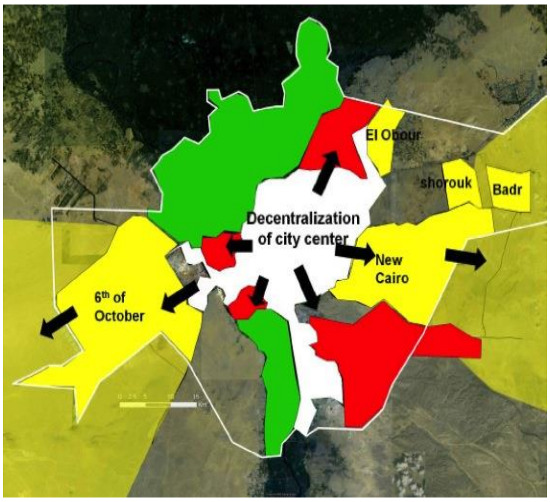


Figure (3) Protection and preservation of planned areas in Cairo and Giza

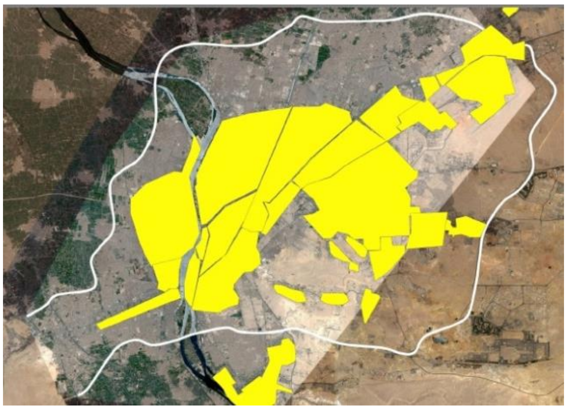
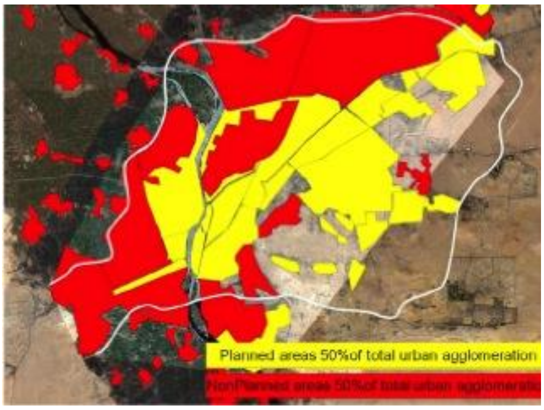


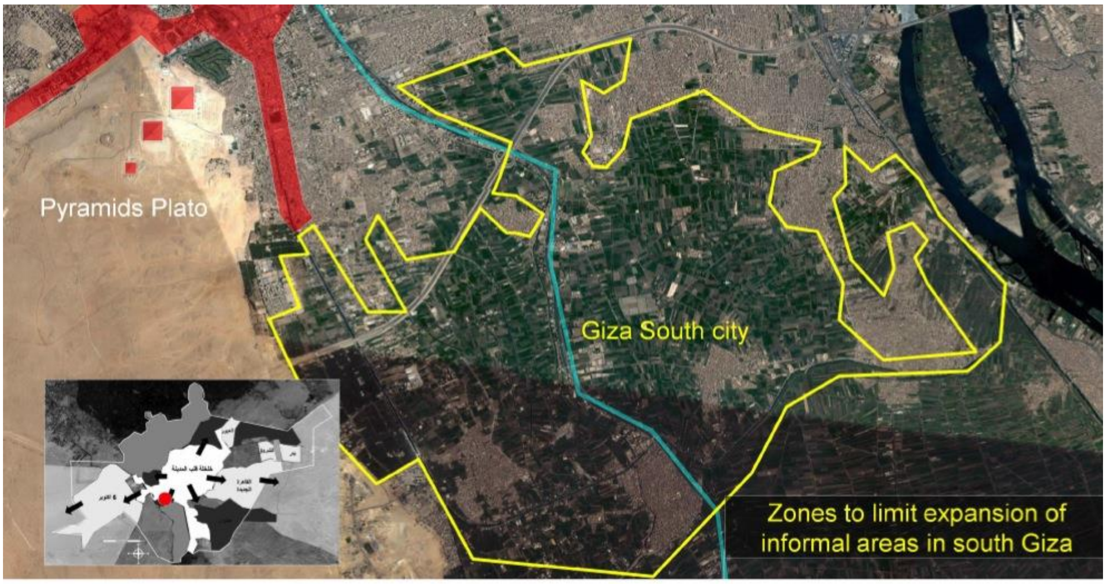
Figure (4) Controlling the extension of the informal unplanned areas.

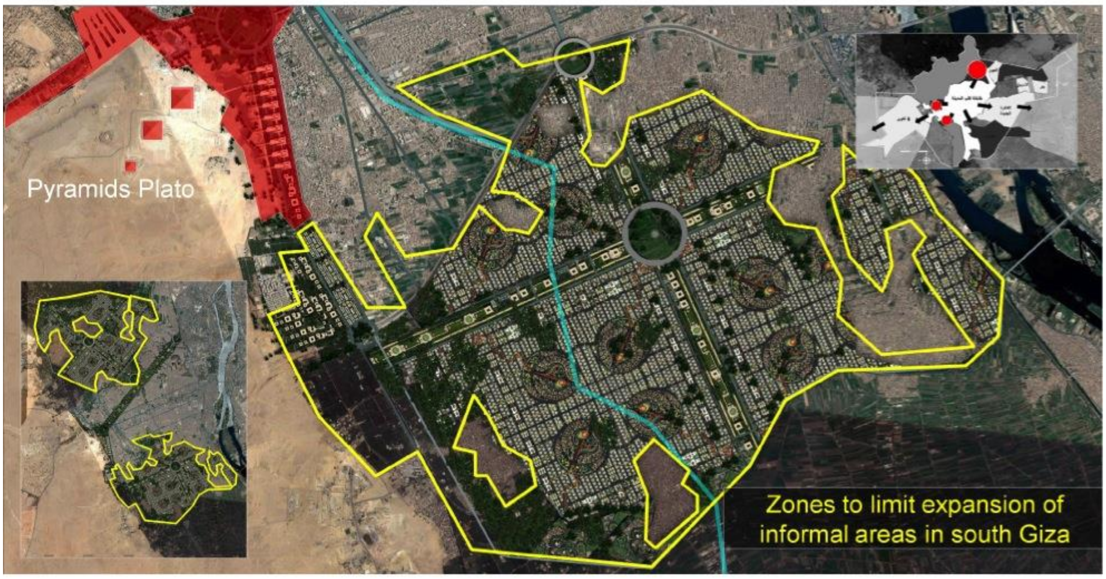


The proposal identifies a strategy to control further expansions of the informal city through building planned middle class housing projects along the informal city peripheries. This proposal prevents the expansions of the informal city, which is originally illegal as it allows building on agricultural land, which is illegal. Yet, the proposal builds on the residual agricultural lands to do so, which is supposed to be illegal according to the law.

In addition to that, according to the past experiences, the informal city grew in contact with the formal city as it depends on it in the provision of main services, and when the ring road was constructed as the new city periphery, to prevent further expansions of the city and especially the informal one, on the contrary, the informal city grew around it and it increased the market valur of the agricultural lands nearest to it. So, this proposal might be a reason for further extensive expansions on agricultural land.

Figure (5) Cairo Vision 2050 for South Giza





Hence the political order contributes to the reproduction of informal Cairo in two respects. First, the exigencies of authoritarian rule and clientelism constitute a substantial part of its conditions of possibility and shape its characteristics. Second, as observed in the upgrading case studies, these same exigencies have obstructed the introduction of more sustainable forms of urban governance. In short, the informality of Egypt’s post-1952 politics has tended to informalize Egyptian society.

Yet ironically, this very combination of state-society informality has also created the conditions of possibility for the popular agency. The durability and tenacity of informal Cairo is, to a large extent, the effect of an incompetent and indifferent state, the potential administrative capacities of which have been subverted by the survival strategies of the political elite. The people in informalities have been able to resist removal if for no other reason that the state has few options in dealing with them. The neglectful nature of its rule has foreclosed alternative governance strategies. (Dorman, 2009)

However, these strategies that objectify the informal communities and lack a deep understanding of the social structure and the needs of their inhabitants, were the main reasons beyond the extensive growth of the informal city. Yet, this was also prevalent in the futuristic vision of Cairo 2050, which signifies that policy makers are still unable to understand the patterns and the logic beyond informalities phenomenon and so unable to provide possible solutions for developing these areas and their relation to the rest of the city.

Formalizing the Informal City

The informal city being an illegal city built on agricultural land has always accepted to be marginalized and under-serviced. Yet, they have always found a way to put pressure on the government through the parliament representatives, who bring their demands to the government and provide them with services and the basic infrastructures, in return to their votes and so their seats in the parliament . Actually, this strategy did work and most of the informal city is provided with clean water networks, sewage systems, electricity, and even some of them have natural gas networks that are not yet provided in some of the formal city parts. Yet, the informal city is still deprived from most of the governmental services whether educational, municipal, or health facilities. They always tried to provide informal or private alternatives for them; yet, the needs of the informal city inhabitants (which are assumed to be 70 per cent of Cairo's population) were never fulfilled.

In summer of 2000, an unexpected environmental protest took place in Giza City, on the wet bank of the Nile in Greater Cairo. A group of several hundred residents of an informal area in the Pyramids district called 'Amr ibn al-'As converged in front of downtown government offices, holding placards that said, "No to fear, No to sewage, No to pollution" ("Saying No to Pollution", 2000). Expressing outrage over a problem that afflicts informal areas as their population density increases, the residents' signs alluded to the sewage that had submerged their dense neighbourhood streets over the previous eight months. Having tried a self-help strategy up to that point, they were driven to protest when the flooding triggered an electrical fire and fire trucks were unable to access the area because of the waterlogged, unpaved streets. (Bell, 2009) The residents blocked traffic for hours, eventually gaining access to the offices of Giza governorate officials and their representatives for a face-to-face meeting. The authorities agreed to dispatch dredging trucks to temporarily ameliorate the problem. Residents remained there until the trucks were dispatched. Later in the week, the authorities announced a comprehensive sewage plan for the area. The residents had been successful in prompting the city to put their neighbourhood on the 'map,' achieving formal recognition and promises from the city to provide them with services integral to modern urban life.

However, to understand the significance and extent of such phenomenon, one needs to go back to the weeks and months immediately after the 25th of January Revolution. The so-called popular committees, which had been formed in almost every street or neighbourhood to defend their homes and properties when security forces had a total meltdown, had subsequently evolved into broader coalitions of youth and active citizens gradually shifting their focus and mandate from security questions to development and awareness-raising efforts. In the absence of active and transparent bodies of local governance, these coalitions or initiatives have become an alternative forum for debating and negotiating competing interests and often conflicting priorities in such communities.

Then during, the 25th of January revolution, which called for bread, freedom and social justice, the informal city community have participated and provided it with the critical mass, and thus allowed the revolution to continue and forced the regime to step down. This drastic change in the whole nation was one of the reasons to raise the awareness of the informal city community of their rights. In addition to that, the failure of the state security system has allowed the informal city inhabitants to practice a number of initiatives that express their needs and will to expose themselves and get formalized. They range from the simple encroachment on sidewalks and streets, horizontal and vertical extensions to existing structures and premises, building on state land or privately-owned agricultural tracts, to the construction of highway exits and other infrastructure projects entirely by local community effort.

A distinction could be drawn between two levels of interventions. The first include individual efforts and encroachments on public space, such as tea stands, food stalls, street vendors and informal parking regulations, whereby many shop owners and some residents 'reserve' the area outside their premises as their own, or at least for the exclusive use of their customers/guests. The second level, however, involves interventions by groups or communities, which entails higher level of collaboration and coordination, and often more complex network of fundraising and organization. In some cases, the type of interventios also involves more sophisticated construction or engineering systems, such as the construction of mega sheds, raised platforms or ramps. Two example of the latter are worth noting.

For some observers, self-created working-class neighbourhoods may evoke the notion of urbanity without planning, development without a soul, and dusty roadways deserted by cars and mobbed with chaos. These myths of informality, underdevelopment, and rurality weigh on these communities, which have access neither to public services nor to the public sphere in which to challenge their status and representation as 'illegals'. These local societies are supposedly either hyper-passive or dangerously explosive, thus contrasting forms of contact and disjuncture with spaces of hegemonic power at the urban, national, and international scale. The tensions and inequalities between urban spaces categorized as informal/illegal and those normalized but riddled with infralegality are aggravated by the circulation of resources and expertise associated with globalization (Deboulet, 2009). The force of globalization and metropolisation has expanded urban spaces across ever growing territory without offering increased means of connecting laborers with jobs or goods, with markets.

Non-recognized settlements of Greater Cairo now constitute a transclass negotiation space that has begun to challenge the neat spatial frontiers that have marked the city. This erosion of boundaries between 'formal' and 'informal' neighborhood spaces reveals the contradictions inherent in urban studies models of categorization, and the renegotiation of urban modernism and developmentalism in law and space between and between international and local norms. (Deboulet, 2009) Existing discourses about urbanity require interventions that establish space for strengthening notions of the 'right to the city' as an essential social and human right. These nascent rights have been threatened, weakened in the brutal confrontation with global development paradigms and neoliberal retrenchment (Sassen, 1999). Nevertheless, the daily struggle and engagement in 'the right to the city' as an essential modern basis for legal subjectivity, social stability, and citizenship continues.

Working-class communities in Cairo have confirmed that through grassroots planning and building, the city can be a shared, governable, and affordable space. But this statement is not valid unless public interventions reinforce local involvement in providing sustainable solutions such as helping to maintain open spaces or providing amenities. In recent years, the scarcity of affordable buildings has led to massive densification of much of the unrecognized settlements and this even stronger for the squatter settlements. Residential densities today exceed one thousand inhabitants per hectare in many parts of Cairo. Added to such densities, the lack of sanitary drainage is causing growing environmental problems when these small communities are not the recipient of public intervention or upgrading of any kind and become giant slums. (Deboulet, 2009)

Finally, in the post-industrial megapolis growing segments of the population remain invisible and unheard (Honneth, 2002). While deepening social and political fractures affect the living conditions of the squatters, the most advanced infrastructure is delivered to those who can afford to turn their back on the megapolis, widening a two-tiered urban citizenship. But Cairo deserves more than the widening economic and environmental fissure between successful Egyptians, on whose behalf urban renewal and costly infrastructure is undertaken in the new desert communities (such as New Cairo), and the anonymous crowd of the deprived in their enclaves. We need to take a necessary step toward recognizing the dignity of the multitude and their useful contribution to the city's shape, structure, and dynamics. (Deboulet, 2009)

6 Conclusion

Based on past trends, the informal city can be expected to keep growing, with an ever-increasing portion of Greater Cairo's inhabitants finding homes and livelihoods in it. Some mature informal areas have pretty much reached saturation, but in many others consolidation and incipient infill continue for years. However, there are two government initiatives that have been launched in the past few years, which might have some effect on informal areas in Greater Cairo. The first is the national Sunduq Tatwir al-Manatiq al-Ghayr Amina (Unsafe Area Development Fund), which was established in late 2008 under the prime minister's office and appears to be well financed. The initiative, aims at redeveloping all dangerous informal areas in Egypt. This is a limited approach that appears to be rationally thought out. For Cairo, it will mainly mean the redevelopment of cliff areas in Manshiyat Nasir and Stabl 'Antar as well as the removal of some slum pockets. Perhaps a total of 250,000 to 400,000 persons in all Greater Cairo will be affected, almost all of whom will need to be resettled at government expense.

The second initiative is much more ambitious and, so far at least, not very well conceived. It is called the tahzim (belting or containment) strategy developed by GOPP in 2007 and 2008, and it aims to allow limited formal urban development on agricultural land around informal areas in order to contain further informal encroachment. Although this strategy represents a fundamental shift in government policy related to the urbanization of agricultural land, it has yet to be applied and will require planning and control mechanisms and institutions that still need to be articulated. Also, unless greatly relaxed standards of subdivision and building are allowed in these tahzim zones, there is the risk of creating yet more areas for private real-estate speculation and little if any affordable housing. In any event, this strategy has yet to become operational even on a pilot basis.

The government has to identify the trade-off between problems and gains that residents of informal areas experience in their daily lives. For two reasons. Firstly, it provides a guide for intervention strategies. It develops understanding of what is working well but needs improvement, as well as what is ineffective and needs to be changed. If intervention is implemented without such knowledge, it might negatively impact certain advantages enjoyed by residents. The second reason is that it allows planners and policy makers to learn lessons in urban planning and development, in that informal areas seem to be the preferred residential choice for many low-and middle-income families.

There are lessons to be learned by professionals, and by their partners and stakeholders, regarding the planning, design, and operation of both formal and informal neighbourhoods, whether for new design purposes or for rehabilitation and upgrade. The first lesson is to recognize people as potential: to invest money, to manage and maintain the physical environment, and to participate in service provision. The second lesson is the need for the government to adopt an enabling approach that supports what people do, and to regulate to the benefit of the collective good. One priority should be the development of enabling /affordable housing standards, rather than standards so unfeasible that they leave most of the housing stock unregulated. The third lesson to be learned from informal areas is the importance of appropriate neighbourhood planning: where street layout and distribution of commercial activities promotes sustainability, where value-for-cost is maximized, thereby allowing residents the opportunity to control and appropriate public space, and where people are encouraged to invest in the shared amenities and maintenance of their neighbourhood.

Thus, the informal settlements turn the simple question of urban planning into an enigma. Indeed, how can local actors, who lack legitimate resources, build common property of the greatest complexity, a space that becomes a city and that resonates as a shared common space? Here, there are at least two hierarchies that must be rearticulated. The first are urban norms of international importance and status, which produce global, national, and local spaces with their corresponding structures and evaluation of collective abilities. Their evident limitations emerge only after construction has begun. The second set of erected hierarchies is internal to the social relations of risk within the community. People grabbing such land had to face the reality of setting themselves up on virgin land and building homes despite the risks of eviction, failure, new and unpredicted conflicts, and parcel swindling. (Deboulet, 2009) Yet, the enigma can also be drawn about what is the possible role of an urban planner in cases of intervention within such structured entities. What can be proposed as a role between the governmental policies and these areas residents and builders? Is there a realistic possibility to develop these areas, that are deprived of the basic services and amenities? And if so, how can the urban planner be the link that connects the top-down policy with the current interventions on ground? What is the possible new urban order?

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