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Roof Planting as a Tool for Sustainable Development in Residential Buildings in Egypt

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Abstract

Roof has direct influence on thermal ease and energy preservation in and around buildings. Roof Planting is a strategy that can be a beneficial solution in diverse climates to decrease energy utilization in buildings, proposes enriching the aesthetic potentials and architecture presentation of buildings and for enhancing the built environment and increasing investment opportunity. It helps to tackle the shortage of green space in numerous areas and delivers the city with open spaces that aids ease heat effect and offers human population with a correlation to the outside. The research problem presented in the demonstrations of the confronts presented by quick urbanization and expansion, many environmental problems as pollution, dense urbanization and heat effect that creates a negative impact on the environment. The fast growing population in Cities undergo from vanishing of green areas which lead to dispossession of open space. The paper assumes that by applying roof planting to the case studies in Residential buildings in Egypt can improve quality of life, as an effective tool for sustainable development goals represented in social, economic and environmental factors. The paper methodology focuses on the analysis of some international examples and the lessons learned and applicability in Residential buildings in Egypt. The research aims to present the potentials of roof planting in abiding electricity utilization and decreasing CO2 releases in hot environments. The paper studies the impact of roof planting on the performance of buildings. The results demonstrate the sustainable development goals of using roof planting under diverse design conditions and postulate assistance for design of roof planting in alike climates.

Keywords

Roof Planting; Sustainable development; Residential Buildings; Egypt

1. Introduction

Combining plants with architecture and formed landscapes have been assimilated into the urban fabric and considered elevated greenspaces have lasted prolonged time ago with architecture (Velazquez, 2005). They are as an easy and efficient approach for enhancing the built environment and rising investment prospect, have several environmental benefits such as to decrease flood risk, develop rainwater runoff quality, lessen urban heat island, building energy saving and keep urban wildlife habitat. (Sheng et al., 2011). The need to apply green roof is significant for the well being of succeeding generation (Ismail et al. 2009). Green roofs are becoming popular for sustainable development.(Sheng et al., 2011).

The usage of vegetated roofs is a solution, which heat energy consumed by evapo-transpiration. It provides to

vertical mingling of air, so the temperature above them inclines than the surrounding areas built. Warm air increases above the hard surfaces and is altered by the renewed air and decreasing the heat island consequence. (Sheweka, 2012)

The building sector has an essential responsibility in the international energy and environmental developments as it occupies almost 40 % of the energy. It is facing a speedy progress in countries throughout the world due to issues like population increase, infrastructure expansion, upgrading and urbanization (Alnaser, 2008). To challenge the fronting of energy and environmental complications, the world is directing to encourage sustainable improvement as is revealed by the current global agreement on climate difference. (Paris Agreement. http://www.cop21.gouv.fr /en/195-countries-adopt-the-first-universal- climate-agreement/ (2017).

The usual roof type in residential buildings in Egypt is the flat roof (Fig 1.). In rural areas, roof tops are used for numerous purposes; pigeon houses, drying washed clothes and in some buildings extra rooms are built from light material and used for living. Some buildings rooftops have been abandoned and become housings for storing litter, a place for satellite receivers and unnecessary old household properties. (Zacharia & Dabaieh, 2016)

Figure 1. Poultry room with red brick; Neglected rooftops in downtown Cairo. Source: https://webpages.uidaho.edu/larc380/new380/pages/greenRoof.html

The paper will show the existing state of the rooftops of the field study and will conclude with a recommendation for evaluation and monitoring in addition to the environmental impact. The above parameters have been explored for residential building blocks situates in Cairo, Egypt.

1.1. Research problem

Air quality amounts in Cairo (Fig. 2.) have demonstrated hazardous concentrations of lead, carbon dioxide, sulphur dioxide, gathered particulate matter levels due to periods of unregulated car releases and urban settlements that devastate ecosystems. Green roof technology encompasses growing plants on rooftops interchanging green spaces that was damaged when the building was created.

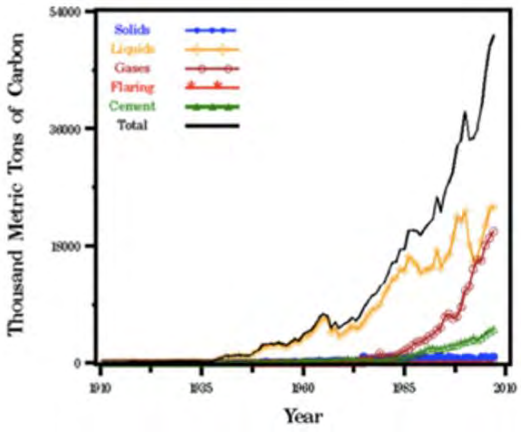


Figure 2. CO2 Emissions from Egypt, CarbonDioxide Information Analysis Center

1.2. Research aim and objectives

The research aims to explore the potential of green roofs on saving energy when invested on residential building in Egypt, reductions of CO2 and sustainable development in residential buildings in Egypt.

1.3. Methodology (Fig. 3.)

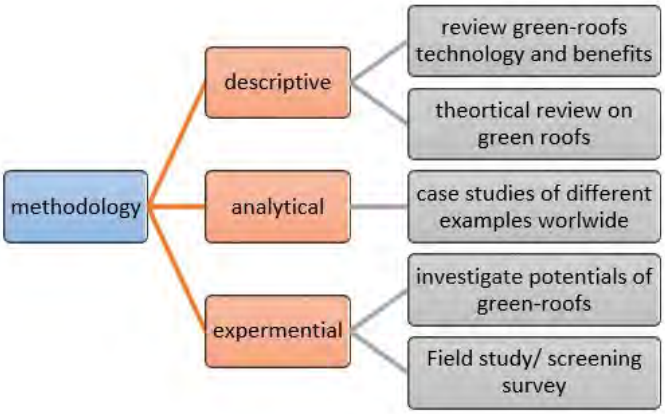


Figure 3. Research Methodology (The researcher)

2. Literature Review

2.1. Green roofs

Green roofs used to cover impermeable roof surfaces with living plant material, considered a sustainable design element in the ecological design that can assist keep the environment by shrinking developmental influences on our societies (Velazquez, 2005). They are envisioned one of the typical methods used in sustainable development principles. (Gedge et al., 2004).

2.2. Types of Green Roofs - Table 1,2&3- (Fig. 4-5 &6)

Intensive Green Roofs Table 1. (http://www.greenrooftechnology.com/intensive-green-roof)

Table 1. Intensive Green Roofs

Characterized by its diversity of vegetation varying from herbaceous plants to small trees with maintenance and green roof irrigation techniques. The growing medium depth is 6 inches or more, propose a huge potential for design and biodiversity. Also upholds from small personal/home gardens to public parks. Plant selection and design affects the maintenance needed for the conservation of these roofs. It requires higher nutrient applications and focused maintenance.	 	
		
Cruise Ships	Peggy Notebeart Museum	Chicago City Hall
Examples of projects of application of Intensive green roof		

Extensive Green Roofs Table 2. (http://www.greenrooftechnology.com/extensive-green-roof)

Table 2. Extensive Green Roofs

Is characterized of its vegetation, extending from sedums to small grasses, herbs and flowering herbaceous plants, require slight maintenance and no permanent irrigation technique. The growing medium depth is 6 inches or less. These systems are best for efficient storm water. They are very cost efficient and best for integrated PV/Solar systems.	
 	
Bronx County Courthouse / Swarthmore College David Kemp Hall	Dansko
It is one of the most popular types of green roof systems. It is a good fit for low-sloped roofs and retrofit styles. They employ fewer and thinner build-up layers, lighter and less expensive systems (Velazquez, 2005).	 Extensive green roof/Camber, Sussex UK
Examples of projects of application of Extensive green roofs	

Semi Intensive Green Roofs Table 3. (http://www.greenrooftechnology.com/semi-intensive-green-roof)

Table 3. Semi Intensive Green Roofs

Characterized by tiny herbaceous plants, ground covers, grasses and small shrubs, requiring adequate maintenance and occasional irrigation. The growing medium depth is 6 to 12 inches. The system is able to recollect more storm water.		
		
Evansville Public Library, Oaklyn Branch	Carnegie Mellon Hamerschlag Hall	Philadelphia Public Library
Figure 6. Examples of projects of application of Semi Intensive green roof		
They are a mix of both extensive and intensive which tend to have both the benefits of each style, with the environmental benefits of a green roof.		

Intensive green roofs have richer soil and extra diversities of vegetation, but are expensive to build and uphold. Extensive green roofs are inexpensive and easier to build and maintain. It encompasses shallow soil, have less collections of vegetation and rarely reachable contrasting its counterpart. (Zahir et al., 2014). Table 4. Summarizes the types of green roofs.

Table 4. Types of green roofs in buildings in cities (https://livingroofs.org/introduction-types-green-roof/)

Type →	Extensive	Semi-intensive	Intensive
Use	Ecological Landscape	Garden/Ecological Landscape	Garden/Park
Type of vegetation	Moss-Herbs-Grasses	Grass-Herbs-Shrubs	Lawn/Perennials, Shrubs, Trees
Benefit	Water, Thermal, Biodiversity	Water ,Thermal ,Biodiversity , Amenity	Water, Thermal, Biodiversity, Amenity
Depth of Substrate	60-200mm	120-250mm	150-400mm
Weight	60-150 kg/m2	120-200 kg/m2	180-500 kg/m2
Cost	Low	Periodic	High

2.3. Example of green roofs types

The follwing table showing types of green roofs used in some buildings in Malaysia (Table 5.)

Table 5. Implementation of green roofs in Malaysia (Zahir et al., 2014)

Building	Type of Green Roof	Architect	Year
Rice Garden Museum (Laman Padi), Langkawi.	Intensive	-	1998
Ministry of Finance, Putrajaya.	Extensive and Intensive	GDP Architect.	2002
Putrajaya International Convention Centre (PICC).	Intensive and Extensive	Hijjas Kasturi Assc.	2003
Putrajaya City Hall, Putrajaya.	Extensive	ZDR Architect.	2004
Malaysian Design Technology Centre (MDTC), LKW, Cyberjaya.	Extensive	Llewellyn Davies Yeang.	2004
Serdang Hospital.	Intensive	Gabungan Architect.	2005
Faculty of Social Sciences and Humanities, UKM.	Retrofit Extensive	-	2007
Sime Darby Oasis, Damansara.	Extensive	GRA Architect.	2009
KL Sentral Park @ Platinum.	Intensive	Perunding Alam Bina & Cox Architects.	2009
Newcastle University Medicine Malaysia, Nusajaya.	Extensive	MAA Architect.	2011
Laman PKNS, Shah Alam.	Intensive	Veritas Architect.	2013
Heriot-Watt University, Putrajaya.	Extensive	Hijjas Kasturi Assc.	Expected in 2014
Tun Razak Exchange (TRX).	Intensive	Arkitek Jururancang & Machado Silvetti and Assc.	Expected in 2016

2.4. Components of green roofs

Table 6. A green roof layer differs from design to alternative but usually it is made up of six layers.

1	Structural roofing deck
2	Waterproofing coverings that preserve moisture out of the structure
3	Root barriers that avoid from obstructing the waterproof seal
4	A drainage system transports away extra water
5	A filter fabric avoids soil particles from washing away in the rain
6	The substrate that upkeeps the plant life and aides in water retention

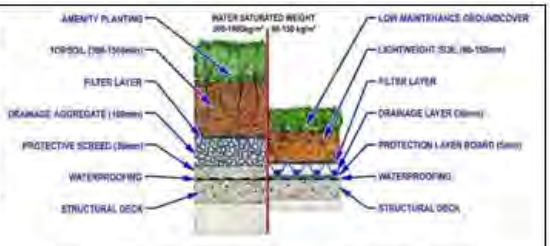


Figure 7. Green roof layers (URBIS, 2006, ADAPTED FROM DRAWINGS FROM Greenlink Kusters Ltd.)

3. Benefits and Challenges of green roof

There are many benefits for implementing green roofs (Table 7.) and factors considered when applying green roofs (Table 7.)

(https://www.gsa.gov/portal/mediaId/158783/fileName/The_Benefits_and_Challenges_of_Green_Roofs_on_Public_and_Commercial_Buildings.action)

Table 7. Benefits of Green Roofs (Getter & Rowe, 2006)

Reduced Volume of storm water runoff	Much of the precipitation is taken in the plants and will evaporate from the soil surface. (Connelly & Liu, 2005; Villarreal & Bengtsson, 2005).
Delayed stormwater runoff	Green roof systems preserve storm water, runoff still happen after the media turn out to be saturated, runoff is postponed as it takes time for the media to become saturated and for the water to drain through the media, which stop storm water sewer systems from overflowing.
Increased life span of roofing membranes	Keep roofing coverings from solar exposure and ultraviolet emission that can destruct the conventional bituminous roof membrane. These materials also decrease temperature variations, which reduces the stress of daily expansions and contractions.
Energy Conservation and the urban heat island	offer shade and protection, aid in energy savings and improvement of the urban heat island effect, depth, shade from plant material, and transpiration can lessen solar energy increase by up to 90% related with non-shaded buildings. (Dunnett & Kingsbury, 2004).
Increase biodversity and provide habitat	Most extensive green roofs are unreachable to the public, they can offer unobstructed habitat for microorganisms, insects, and birds.
Improved aesthetic value	viewing green plants has useful health outcomes, such as lessening stress (Ulrich & Simmons, 1986)
Mitigation of air pollution	Plants can screen out particulate matter and gaseous impurities in the air.
Noise Reduction	Hard surfaces in urban areas can reflect sound, while green roofs absorb sound waves.

Table 8 .Factors considered when applying green roofs performance: (Getter & Rowe, 2006)

Aesthetics appeal	Visual appeal is important designed for public. The aesthetic significance of the roof will persistently alter through the season and throughout time.
Environmental conditions	Climate and microclimate have a major impact on plant selection. Environmental conditions will reduce the consumption of certain species and command the necessity for irrigation.
Substrate composition and depth	Substrate composition has a main influence on plant selection. The ultimate substrate is involved of a stability of lightweight, well-drained material, has satisfactory water and nutrient holding capacity, and will not break down over time. (Beattie & Berghage, 2004; Dunnett & Kingsbury, 2004).
Plant selection	Measures for choosing plant material enclose design intent; artistic attraction; local environmental circumstances; plant features such as degree of formation, durability; and the substrate configuration and depth accessible for planting. (Dunnett & Kingsbury, 2004).
Installation methods	Plants can be started directly upon the green roof media. Otherwise, vegetation can be pregrown at ground level in the shape of a blanket and then located on the roof.
maintenance	

4. Sustainable development application in Architecture

Figure 4. Sustaianble development components

Sustaianable development is a arrangement of progress in which reserve usage commitments to meet human needs while maintaining the environement, these requirements can be met only in the present and for generations to come (Fig. 4). (Obiefuna) To achieve sustainable development, buildings must be designed inclusive of the concepts of development. Such buildings will have a positive impact on the environmental health at communities and the quality of life. The concept of Sustainability challengees architects to think and act in terms of long-term consequencesof their decisions on the diminshing resources of the world. (Dunnett & Kingsbury, 2008)

4.1. Green roof's role in sustainable development (Sheng et al., 2011). Table 9.

Table 9. Case Study of applying Green roof in Malysia

<table>
<tr>
<td>The application of the green roofs approaching the flat soil with vegetation reduce the peak rainwater runoff and flood risk. Cities in Malysia are facing UHI outcome as more green spaces are taken up for progress. Green roofs can offer consistant passive thermal resistance for buildings and environment, they have the prospective to aid reduction the uprising global warming consequences.</td>
<td>
<table>
<tr><th>Type of Surface</th><th>High</th><th>Low</th></tr>
<tr><td>Roof:</td><td></td><td></td></tr>
<tr><td>Metal, gravel, fiber glass, mineral</td><td>0.95</td><td>0.9</td></tr>
<tr><td>Paving:</td><td></td><td></td></tr>
<tr><td>Concrete, asphalt</td><td>1.00</td><td>0.9</td></tr>
<tr><td>Gravel</td><td>0.7</td><td>0.25</td></tr>
<tr><td>Soil:</td><td></td><td></td></tr>
<tr><td>Flat, bare</td><td>0.75</td><td>0.2</td></tr>
<tr><td>Flat with vegetation</td><td>0.6</td><td>0.1</td></tr>
<tr><td>Lawns:</td><td></td><td></td></tr>
<tr><td>Flat, sandy soil</td><td>0.10</td><td>0.05</td></tr>
<tr><td>Flat, heavy soil</td><td>0.17</td><td>0.13</td></tr>
</table>
Typical Values of Runoff Coefficients (waterfall, 1998)
</td>
</tr>
<tr>
<td colspan="2">Above half of solar increase by low height building like a typical terraced house is throughout its roof, as it obtains the greatest solar emission and for the longest period over the day. Old buildings in Malaysia retrofitted with green roofs as buildings not conforming to the 2006 UK building guidelines will have much lesser U-Values connected with reduced roof isolation.
New constuction should contemplate green roof as a green building design method at the same time saving the charge for usual roof isolation. The energy benefits offered by the green roof possibilities furthermore create a noteworthy effect in the life cycle evaluation. The primary function of green roof is to deliver a visually exciting vegetation layer of different texture and seasonal colour changing a rock ballast or dark exterior.</td>
</tr>
</table>

4.2. International Case Study: Table 10. Shows some examples of case studies

Table 10. Case Studies (https://resources.realestate.co.jp/living/japan-green-roof-buildings/)

Project	ACROS Fukuoka Prefectural International Hall, Fukuoka, 1994, Commercial, designed by Emilio Ambasz. Ambasz	Namba Parks, Osaka, 2003, Commercial	Villa Rouge, Japanese seaside, 2010, Residential, architects, Ciel Rouge	Roppongi Hills Rooftop Garden, Tokyo, 2003, Mixed-used, Minori Mori
Description				
	Examples of International projects application of green roofs			
	A center of international, cultural and information exchange. Under the park's terraces lies multiuse space comprehending an exhibition hall, a museum, a theater, conference facilities, governmental and private offices, numerous underground stages of parking and marketing space.	A giant terraced green space and retail and office complex built on Osaka's old baseball stadium, the development was intended as a huge inclining park that links to the street, reassuring pedestrians to enter its numerous city blocks.	A private residence and a private museum and guesthouse. It characters a permeable facade that admits the interior to experience the wind and natural light and to stipulate panoramic visions of the surrounding landscape. Cross ventilation is attained throughout an inner garden.	"Vertical Garden Cities" re-development idea, which pursues to form environmentally friendly cities and to increase exposed space in Tokyo's high-density centers.
Advantages of green roofs	Formed a new resolution for a common urban problem, by undertaking the wish of a site with the public's necessity for open green space.	The development contains of a 30-story office building and a big shopping mall topped by a roof-top park extent throughout several blocks, progressively arising eight levels, inventing a green oasis in a high-density urban area.	A 40cm thick roof garden, which hosts 500 m2 of solar panels, as environmental protection and concealing the physical frontier amongst architecture and landscape.	Rooftop gardens, to provide occupants to an opportunity to involve in an activity, readily accessible to urban residents and to help lessen the heat island effect.

5. Roof Planting Implentation in Egypt

As a result of the steady increase in population, required an increase in the number of buildings, resulted in a sharp decline in green areas, followed by many problems. Air pollution arises with increased use of environmentally harmful materials. This has negative impact which affect the city's climate and deterioration in the mental healthiness of the body due to the overcrowding, shortage of oxygen and the lack of green areas.

There are several local initiatives that have worked on the idea of rooftop container gardens for producing food for domestic use. The first rooftop gardens in urban areas in Egypt started in the year 2000 under the leadership of the Research Unit for Agriculture Land and Ain Shams University, in collaboration with several local NGOs (Bekheit & Latif, 2013). The (FAO) Food and agriculture organization and MALR established the project titled "Green Food from Green Roofs in Urban and Pre-urban Environments" to develop and demonstrate simple rooftop micro-green systems for vegetable production in two pilot sites: Alexandria and Cairo (Bekheit & Latif, 2013).

Numerous case studies characterize successful projects applied by diverse non-governmental organizations (NGO), public institutions and private civil proposals. For example Ibn Kassir foundation, in Al-Zawya Al-Hamra, Cairo, formed a roof farm from wooden containers (barrels) with plastic layers occupied with peat moss or perlite used as substrates drainage is compelled through small plastic hoses to buckets. The producing leafy crops as parsley,

radish, and carrots. (Attia et al., 2009)

In several Arab cities, many problems endure including environmental, social and economic. The methods for application are modest and feasible and cost effective. The utmost essential issues affecting are the climate, the constructional and economic aspects, and providing support and sustainability to resolve various complications of diverse background and characteristics, and stipulate to abounding the quality of life of the condensed Arab cities. (Attia et al., 2009)

In Egypt, soil-less cultivation is used to nurture plants atop the roofs of buildings. Plants are produced on wooden tables, delivering a healthy and fresh source of food in addition with no pesticides. Vegetebles and fruits can be produced as self production for building occupants (Fig. 5), furthermore several projects are organized in schools as an overview to this technology. (A. Monem, 2005)

Figure 5. Source: Central Laboratory for agricultural climate (2006)

There are many positive effects of surface cultivation on the environment:

1. Leads to a reduction in the amount of pollutants present in the air.

2. Increases the oxygen ratio and reduces carbon dioxide by urban air.

3. Leads to the cleaning of roofs of different buildings and facilities and the disposal of waste and fouling stored on surfaces and adversely affect the public health of the occupants of these buildings in the long run.

4. Reduce the effect of the Warm Heat Island, which is clearly evident during the summer months in large cities where a clear change in weather is the most important sign of the city's warming up to 5 ° C. Figure 6.

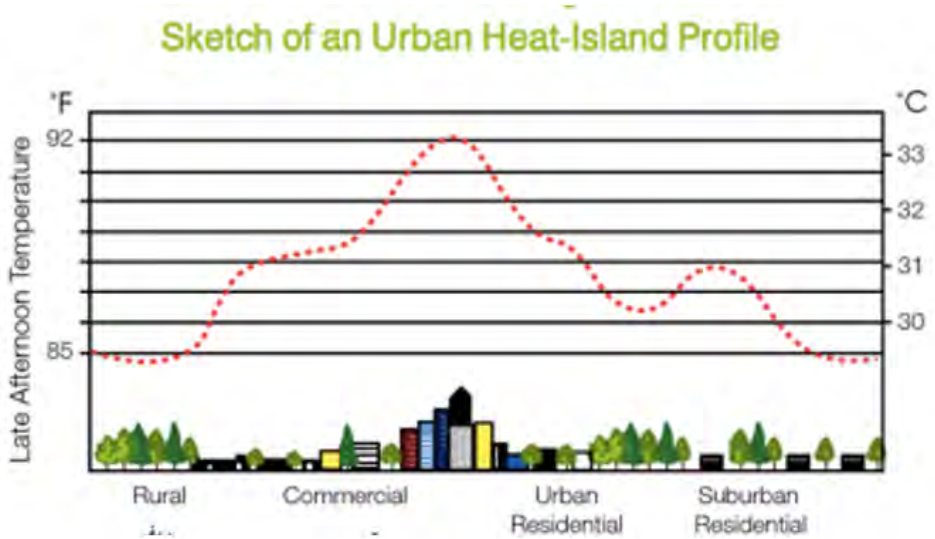


Figure 6. Studies have shown worldwide that the phenomenon of (Urban Heat Islands)different negative effects, including the following:

For Public Health	For the environment
Urban Heat Islands (Urban Heat Islands) cause a high temperature gradient that affects the public health of city dwellers. They may be exposed to sunstroke during the day or cause serious psychological damage that sometimes leads to death, particularly to older people.	High temperature increases the level of harmful substances in the atmosphere, stimulates the formation of ground ozone (in the air), and increases the presence of smoke, which are harmful to the environment.
The cultivation of roofs of buildings and structures in cities reduces the effect of the warm island phenomenon by shading the plants to the surface of the building or the house, as well as the process of transpiration. To the outside air, thereby softening the atmosphere surrounding the roofed building.	

5. reduces the harmful effects of mobile stations where plants are found to absorb electromagnetic waves emitted from industrial plants.

6. reduce the noise ratio and the proximity of the nearby areas of the airports and trains which leads to absorption of a large part of the sound and reduces the reflected waves.

7. is a small project that can be carried out by many groups of society such as youth - housewives - special needs - students in leisure and vacations, which makes their leisure time useful.

5.1. Analyzing Residential Building example

Case study: Project Brief, Table 11.

Table 11. Different forms of plantation systems over roofs: (البحيري، ٢٠٠٩)

First: the establishment of roof gardens using farms

Furnace system	System of base tables	production of some fruit trees on surfaces	use some old materials available in the house of a simple garden surface
used for the production of crops that do not require a lot of space for the growth of plant roots such as paper crops such as watercress, cactus, It is also possible to cultivate more than one plant species in the same place.	used in the cultivation of plants that need a relatively large space to grow the roots of plants, including: tomatoes, cucumber... The single tabulae can be divided so that each group of seeds is grown with a specific crop, with small quantities of different crops at the same time and from the same area.	Used to produce some fruit trees for home use such as lemon, grapes... The bottom of the drum filled with gravel and the rest of the inner cavity completed for the barrel of the environment to be cultivated.	
			

Second: Constructing roof gardens using water farms

1. Static aquaculture	2. Moving aquatic plantations (nutrient film)
The plants grow in a container containing deep water, in addition to the nutrient solution, which is responsible for supplying the plants with their different needs of different nutrients, where the roots of the plants are immersed all or most of them in the water. This system fits in development of strawberry plants, lettuce, beans.	Nutrient-laden water revolves around plant roots in the form of a thin layer that does not cover more than one third of the plant's lower roots. Plants get their water, nutrient and oxygen needs in balanced proportions. is suitable for the growth of plants that are small in size, such as strawberries, tomatoes, characterized by the possibility of increasing the number of plants cultivated in the unit area, which increases the production obtained.
	  Lettuce heads in the hierarchical pipe system installed on the surface of the surface directly    

6. Field Study

A field study showing the current use situation of roof planting on Residential blocks of flats Table 12. & Figure 7.a. to 7.j.. The results shown according to screening questionnaire. Table 13.

6.1. Questionnaire survey Results

Using questionnaire survey (Quantitative Methodology) in order to better understanding of residents preference of function of rooftop garden.(Table .13)Resident's preference of function of Roof top Garden. These tables show the number of 350 respondents, Residents particpated in this survey questionnaire are 300.

Table.12 Field study- Residential Blocks, Egypt

The area chosen is through ring Road from Lebanon sq. till safet ellabn exist; as it witness high traffic through out the day. Most buildings in this area are blocks or private flats covered with red bricks.

7.a
Building blocks aside the ring road

7. d. map showing the filef study area (Google Earth)

7.g. adjacent building blocks so close to the ring road

7.b
Blocks of flats were build in red bricks with no place for green spaces

7.h. Using roofs in breeding birds or as a store of old furnitutre

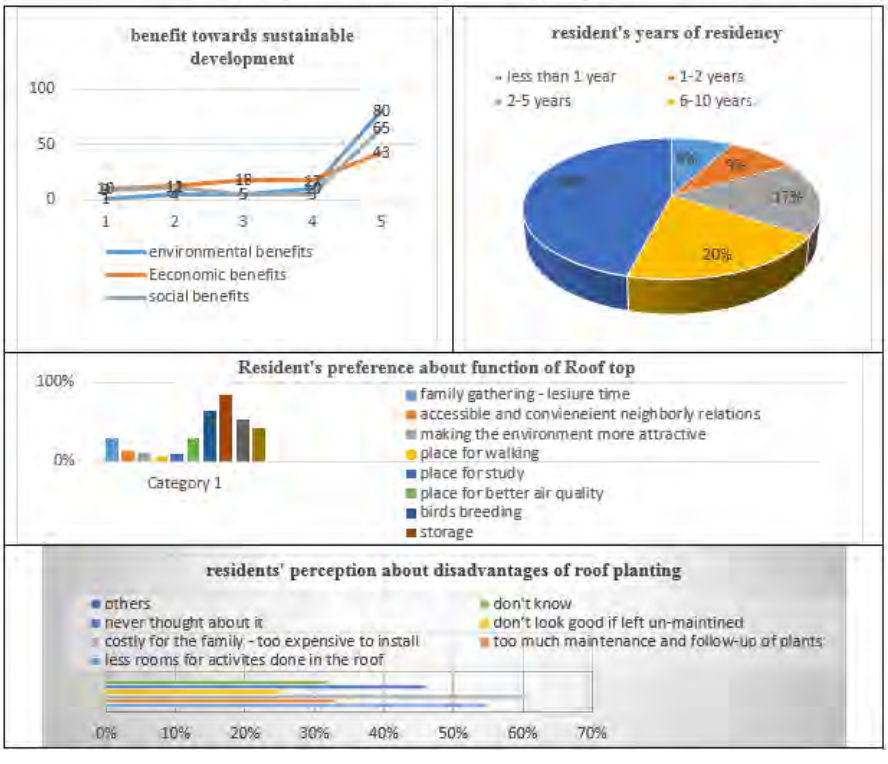
7.c
Blocks of flats were build in red bricks

7.f Usage of roofs in solving problems of high poputation rate in building more rooms to fit all family members.

7.j.Dusty weather is one of the major problems that increase rate of pollution

Figure 7. (from a to j): The field study for roof planting application to convience the residential users who have faced problems (health, pollution,..)

Table 13. Results of the screening questionnaire applied by the researcher



7. Discussion

Applicability of Green Roofs in Egypt in Residential Buildings:

Encouraging interaction among industry professional, public policy making, need public awarness of green roofs, The cost can be twice as much to install, there are other benefits to owners of buildings as saving energy. Added benefits include: stormwater managmnet, ecological, economic, aesthetic and psychological issues.

There is a lack of the awarness to the community, building owners and occupants about benefits provided by roof planting. Lack of technical information on how to build them, standards and building codes to green roof design and constrcution.The economic costs of installing green roofs including the maintainace: Lower energy costs due to the cooling effect.

The barriers in green roof implementation: architects are not convinced of the benefits. Moreover, the lack of policies and guidelines, the government has not enforced it in the Building By-Law. Application restrictions from the client and the problems to persuade them. This technology is considered new and the nonexistence of resource has upraised the rate of installation and maintenance. Absence of knowledge in roof planting technology. Nonexistence of need in the construction industry market.

8. Conclusion and Recommendation

Roof Planting is one possible technique to reduce the devastation of natural habitats, while foster the built environment. Roofs represent 21% to 26% residential and nonresidential of urban areas (Wong, 2005) they stipulate an exceptional chance. These unused areas may develop an approach to regain habitat that was lost as a consequence of construction whereas furthermore assisting in the securing the environment throughout additional sustainable performs.

Aesthetic Benefits	
	The refurbishment and renewal of cities should comprise adjusting outdoor architecture to encounter the needs of communities. Visual Relief: can create pleasing, vigorous, naturalized plant communities.
Environmental Benefits	
	Improved water quality and less overflows of collective sanitary and storm water sewage schemes, Increased habitat encouraging biodiversity, lesser temperatures for Building roofs, Reduced energy consumption in certain climates, developed sound absorption in top floors of buildings, promoted air quality
Psychological Benefits	
	can nurture the built environment, aid clean the air and water, and support energy efficiency, construct ecologically sustainable locations, create improved use of cultural and natural means and materials. Appealing to Biophilia - A connection to nature, being able to view and experience nature, help visually ease the stress and increase calm. Creating sustainable collaborating community areas in which people can interact to visit, play, and relax.
Economic Benefits	
	Increased Roof Longevity: The numerous levels keep the waterproofing coating and structural elements from destructing ultraviolet rays, wind, and temperature variation extremes.
	Reduced Energy Consumption and Costs: Thermally insulating offer energy savings can decrease peak energy request by decreasing cooling and heating requirements, at least for the floor straight underneath the green roof.
	Improved Developable Space: can decrease the needed size of unappealing, space wasting, and costly retention ponds or underground galleries.
	Green roofs as Storm water Mitigation Measures
	Increased Points in the LEEDTM Rating System
	Increased Building Marketability: spaces with the enriched natural vision can assist greater rent rates and help retain improved levels of residence. Resale prices increase too.
	Emerging Synergy with Solar Power: only will exploit on the technologies' energy usage decline prospective and will aid generate a renewable energy source without employing more land.

Roof planting has a positive impact on social, economic and environemental issues. This research illustrates

the majority of filed study residents who particpate in the survey questionnaire, they need awarness concerning advantages and benefits of roof planting towards sustainable development. This study help residents to receive better environement on their living areas.

Recommendations

The necessity to decide the kind of plants and system of planting is crucial in constructing green roof. Depending on particular climate and surrounding, the appropriateness of plant species for roof planting in certain countries should be determined. The correct plant selection assists preserving the sustainability of roof planting. The principal apprehension of modifying diverse kind of plants are utmost essentially amongst soil and kind of plants involved in diverse climate such as temperate, tropical, dry, polar and highland climates. Furthermore, should be considered are the maintenance, financial, and life cycle analysis of the roof to be planted.

Appendix A. Roof Planting application (Screening Questionnaire)

September, 2017 – Cairo – Egypt

1- What is the age of this home?

Less than 1 year	1-2 years	2-5 years	6-10 years	More than 10 years

2- What best describes the uses of the roof in your residential block?

3- Resident preference of function of rooftop garden

Family gathering- Leisure time and relaxation
Accessible and convenient neighborly relations
Making the environment more attractive
Place for walking
Place for study
Place for better air quality
Birds Breeding
Storage
More rooms build
Other activities like hanging clothes to dry
Others:……

4- What do you think the advantages of using the roof as planting?

More green areas
Use as a business project
Less pollution in the area
More income
Better visual view

5- What do you think the disadvantages of using roof as planting?

Less room for activities done in the roof
Too much Maintenance and follow up of plants
Costly for the family- too expensive to install
Do not look good if left un maintained
Never thought about it
Don't Know
Others: ……

6- Roof planting has many advantages on the long run for sustainable development. It will require less maintenanc and less room to apply. If you had been aware of these advantages would you have been willing to install roof planting in your residential block?
How much do you agree or disagree with each of the following?

	1	2	3	4	5
Roof planting will make economic sense					
Roof planting will require very little mainatince					
I like the idea of helping the environment and help in sustainable development					

7- To how extent do you think roof planting is beneficial to sustainable development when applied:

		1	2	3	4	5
Environmental Benefits	Increase biodiversity					
	Improve air quality					
	Reduce carbon and urban heat islands					
	Improve resiliency in urban watersheds					
Economic Benefits	Increase business					
	Create new jobs					
	Increase property value					
Social Benefits	Provide more recreational/social opportunities					
	Increase user's satisfaction					
	Sense of place					

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