

Research Article

Green roof towards increasing Share of Green Area in Cairo with simulation study to decrease the building temperature

Marina Morcos[†]*

[†]Architecture Department, Higher Institute of Engineering El Shorouk Academy, Egypt

Received 01 Nov 2021, Accepted 10 Dec 2021, Available online 13 Dec 2021, Vol.11, No.6 (Nov/Dec 2021)

Abstract

Green urban spaces are the major reasons for more healthy and sustainable city, however the urban development cities suffers from the rapid increases in the urbanization, and decreasing in the ratio of the green space which leads to a delay in the development process in all the aspects economically, socially and also environmentally by increasing in the temperature degrees. The main aim of this study is to put an outline to increase the share of green area and spaces by applying the concept of green roof and urban roof farming in addition to enhance some of the environmental problem such as air pollution, solid waste along with high temperature in the building using design builder program to mitigate the climate change and adapt to reduce the air pollution the environmental and carbon as well as greenhouses gases before using the urban roof farming and after which will be a way to achieve more sustainable and healthy cities.

Keywords: green urban spaces, healthy city, green roof, air pollution, high temperature.-conditioner, In-mold, Inoculant's efficiency.

1. Introduction

Green areas are considered to be green a lung for the city and its protective shield from all kinds of pollutions, as well as many diseases. In addition, the quality of life is raised depending on the share of green areas for the residents. However, the Cairo Egypt suffers from the urban population, as well as lacking green areas, which lead us to many environmental, social, economic problems. As the share for green area for person is equivalent to 0.33 m² per person and this share is considered to be one of the lowest shares in the world (Attia&Mahmoud,2009).

And the decrease in the green spaces shares happened because of the rapid increase which may exceeded the needing of the green as there is study indicates that by 2050 the ratio of the urban areas will be increased from 46.6% to 69.6% and this will lead to environmental problem as air pollution climate change and urban heat island effect (Nations,2007) so by using design builders program as a way to decrease the temperature inside the building and increase the shares of green spaces which will help in the development processes in all the aspects economically, environmentally and socially.

1. The Concept of Green roofs in Egypt

The roofs of the buildings in Egypt are either unutilized or inefficiently poorly utilized. Sometimes, people used roofs as an area for garbage, old building materials or an area for building services like water tanks, satellite dishes. These areas could be thought about in the lack of green areas share among the city.



Fig.1 Rooftops of different buildings in Cairo showing rubbish, Trash and many satellite dishes

1.1 Green Roofs Definition

Green roofs are those roofs that wholly or partially covered with greenery and soil or it can be a growing medium over a waterproofing membrane. The demand for the roof garden is taking the sights all over the world as it is not only a fashion fade but although a thousand of square meter can be planted and absorb carbon dioxide, reduce building temperature release oxygen and insulate building. (Kafay,2010)

*Corresponding authors' ORCID ID: 0000-0000-0000-0000
DOI: <https://doi.org/10.14741/ijcet/v.11.6.8>

1.2 Green Roofs Benefits

Green roofs have many benefits, including:

- Reduce the air Pollutants in the air
- Protect the building from the harmful sun rays
- The square meter of a greenery in a roof top leads to 100 gm. filtration per year of air pollutants.
- Protect much better protection for the roof from the ultraviolet radiations and every day intense temperature fluctuations
- Reduce the effect of urban heat island by shading and cooling the building
- Reduce the diseases, especially respiratory system diseases, as result of the increase in the amount of oxygen
- Provide extra open social spaces also recreational spaces
- Help to make the living space more comfortable and pleasant in the urbanized areas by reducing the noise in big urban towns
- Help to control temperatures, as it saves up to 50% cooling costs in the summer, and 25% of winter heating needs. Researchers found the surface of experimental green roofs were between 2°C and 5°C cooler during the day (depending on substrate type and depth) and were generally more cooling than the ambient air temperature(Grant G. & Gedge D.,2019)



Fig.2 Green roofs add many valuable benefits to the building

2. Green Roofs Types

Green roof types are divided into three categories are Semi-Extensive, Intensive and Extensive.

2.1 Semi-Extensive

It is designed with environmental benefits of an extensive green-roof with larger plants and thicker substrate 20 centimeters than an extensive green roof (Dunnett, 2004).

2.2 Extensive Green roof

Those green roofs have a limited centimeters of the soil, the depth of the soil is rarely greater than 15 centimeters thick are more common to use as roof top garden

- Extensive Green roof garden not designed for people’s interaction

- Planted with planted with low lying and drought-resistant ground cover plants chosen to introduce the site-specific needs and constraints. (Dunnett, 2004)
- Maintenance is rare but varies depending on the kinds of plants used. Occasionally,
- It weights from 50-150kg/m².

2.3 Intensive Green roof

Those green roofs have a limited centimeters of the soil, the depth of the soil is 50 centimeters thick or more.

- Intensive green roof must be taken in consideration the design loads before construction of the building and it can be problem to apply it on existing building due yo the huge loads by adding live and dead loads
- Intensive green roofs are designed to handle and maintain a load of groups of people using the roof for different activities(Scholz-Barth.,2001)
- It weights from (300-1000) kg/m² and sometimes may reach 1220 to 1465 kg/m²

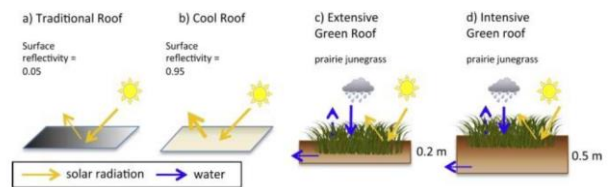


Fig.3 The difference between Traditional roof, cool roof, Extensive and intensive green roofs

3. Green Roofs Structure System

3.1 Modular System

Modular roof system is one of the flexible system and easy to transport and usually are used in extensive roofs it is characterized by quick installation and gives very good fast final rendered image (Lockett K., 2013).

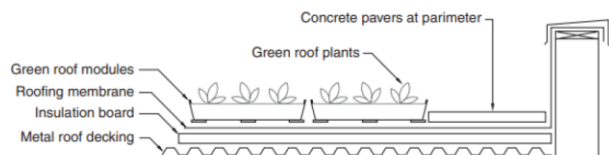


Fig.4 Cross Section modular green roof

3.2 Loose Laid System

Loose laid system is used in designing huge roof projects as the components of each item is installed separately and this system is suitable for all types of roof garden as it has a flexibility and great opportunities in the design

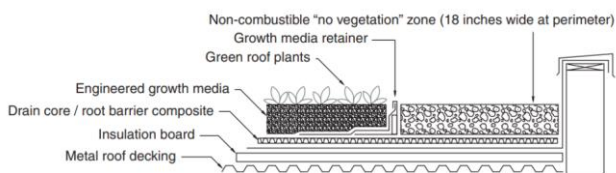


Fig.5 Green roof loos laid installation

3.2 Hydroponics System

Hydroponics system is way of planting using nutrients, water and growing medium like Palm fibers, Peat moss soil, the vermiculite, the perlite and Rice hulls. The word hydroponics comes from “hydro,” meaning water, and “ponos”, meaning labor; this method of gardening does not use soil (Epic Gardening, 2018)

In this system, it does not need any solid medium for root growth, but it uses only the nutritive solution. It uses environments only at the implantation stage and may, therefore, be called plantation of nutrient solution. The plants' roots need three things, water/moisture, nutrients and oxygen

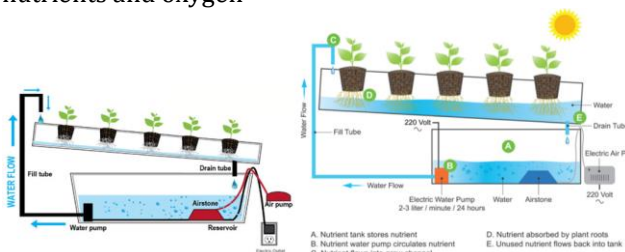


Fig.6 Hydroponics Drip System & Nutrient Film Technique (NFT) System



Fig.7 Hydroponics System planting

4. Challenges facing green roofs application in Cairo

There is many obstacles facing green roofing in Cairo such as the ownership of the building and how has the right to garden the and gains from it's profit and other problems like

- Economic problem :Accessible roofs may need an additional elevator or extra stair , strengtheing of building structure may be required
- Saftety problem :Lack of protection provided for maintenance staff
- Education problem: Training of users/staff is usually required
- Permits Problem:Building/ Roof regulations have to be revised to assure comparability

- Maintenance Problem: it is more difficult to trace if there is any leaking happens to the roof,accessible roofs needs more care as the more complex planting scheme the more attention and care required. (Gawad,I., 2015)

5. Practical Study as an opportunity of increasing the share of green area & solve Environmental issues

This part of the research aims to study the application of green roof which mitigate the climate change and adapt it by reducing the carbon emissions and reducing urban heat island effect, the practical study location informal place called (Mansheya Nasir)by taking one residential building as an application model to know the effect of green roof farming on the climate change, improvement of the quality of life and human health, decrease the level of stress and the increase of the physical and psychological wellbeing of urban citizen This study will be discussed by using (Design Builder program) which mainly depends on.

5.1 Mansheya Nasir (case study)

Mansheya Nasir covers 5.54 km² which is considered to be as one of the biggest slums in Cairo Governments as it is located on “Mokattam hill” bordered with Nasr city to the east, central Cairo districts to the west, it is famous for “Garbage Area” because its economy is based on collecting and recycling the garbage and its citizens suffers from a lot of problem that cannot be ignored as poor urban environment, lack of infrastructure, no running water, decreasing the Hygienic level Problems demand different ways of interventions to solve these problems like using the building in the sustainable process by planting the roof and see the result of the simulation on the climate change and human health by using design builder program.



Fig.8 A Rooftops of Mansheya Nasir buildings showing rubbish, Trash and many satellite dishes



Fig.9 rubbish, Trash on building and streets, un safe entrances, Streets and building

5.2 Case study location and building explanation

The case study is a residential building in front of “Jaberti Primary School “ the building consists of ground a commercial floor and 5 residential floors are with total area of roof surface 565m²and simulation study will be applied on the building to compare between the roof on its current status and after the green roof application to study its effect on many climatic aspects such as (annual sensible cooling, Air temperature, Predicted mean vote, relative humidity)and the study will apply green roof applications such as (Planting in an aqueous medium, Plant nursery tables, planting on potted tables, Pyramid-shaped pipes on nursery tables) by using some recycled material such as barrel, PVC pipes, old wood material by taking into consideration 20% of the roof surface as paths and corridors between pots so the total net planted area will be 452m



Fig.10 shows building locations on google earth application



Fig.11 shows different green roof applications used

5.3 Simulation building by using design build builder application

By drawing the program on the building to perform calculations required and extract the result by insert the basic inputs that indicates a residential building and the calculations applied on adding Green roof.

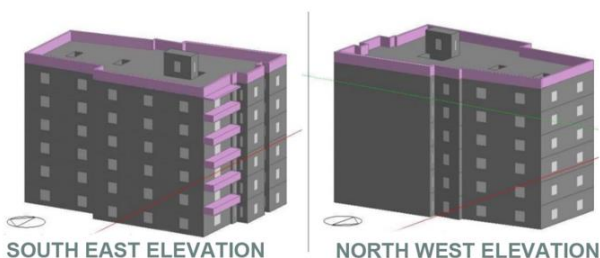


Fig.11 shows the south East and North West elevation



Fig.12 program page shows the a residential activity for the building



Fig.13 program page shows the calculation based on green roof application

5.4 building simulation results using design builder application

5.4.1 Annual Sensible cooling

The effect green roof reduce the energy consumption of the building which appears on the whole building not only on the floor under the roof as the simulation study shows the reduce the energy consumption by quarter . Below normal level and the peak month reduced by 50% which is considered as an achievement

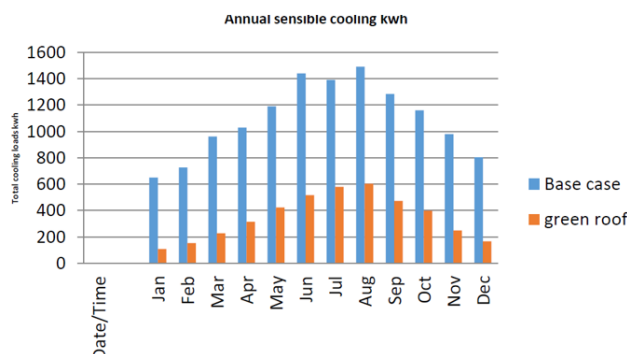


Fig.14 shows the annual sensible cooling before and after using green roof

5.4.2 Air Temperature

It has been recorded the peak of temperature degrees in the summer months before applying green roof and the reduction of the temperature by 5°C which considered to be a very good rate and affective in the climate adaptation process.

Table 1 Temp °C with and without green roof

month	June	July	August	September
GF	26	27	29	27
WGF	28	33	34	31

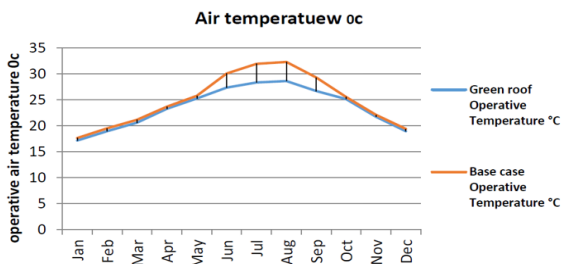


Fig.15 shows the Temperature °C difference before and after using green roof

5.4.3 Predicted Mean vote (PMV)

The known normal and compatible thermal comfort heat PMV rates with humans varies from -0.5 to +0.5 and the result of the simulation after using green roof shows the average thermal comfort for the months of the year are in the logical area allowed range.(Fanger,O.,2013)

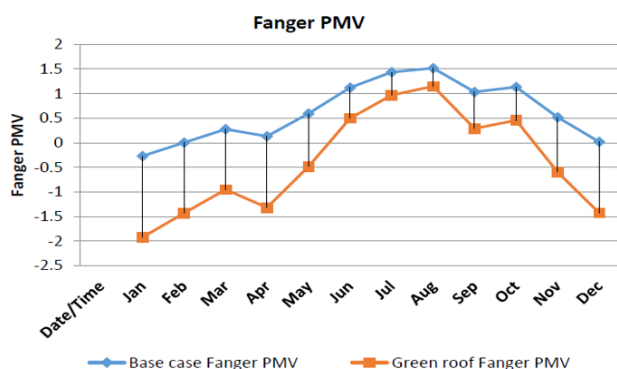


Fig.15 shows the Temperature °C difference before and after using green roof

5.4.4 Relative Humidity

The relation between Relative humidity and temperatures degree is inverse proportion as the higher relative humidity the lower temperature , and this what happens in case of roof garden especially in month 6,7,8and 9 due to the planted surface the rate of evaporation rise also relative humidity and accordingly the temperature decreased which is required

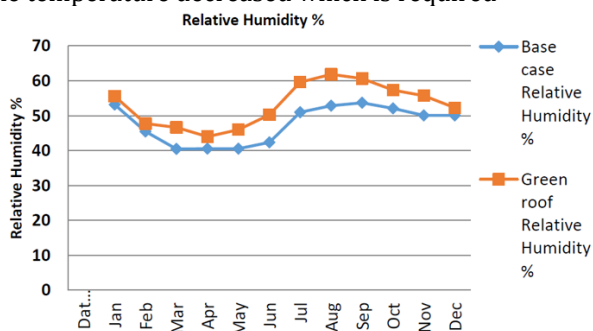


Fig.15 shows the Temperature °C difference before and after using green roof

Conclusions

In conclusion, in Cairo, where many environmental, social, and economic problems exist .but by Increasing the green areas by planting our roof with different types of vegetables and fruits or even a green roof with any green plants or green walls will change many things. Green areas certainly have measurable qualitative and quantitative benefits as long as the implementation techniques are doable and straight forward within the affordable materials like, barrels, tires, and unused wooden material to make pots, unused glasses not only that but also, no green system can be created without the knowledge of the factors affecting the design and construction which are economic, climate, plant selection and constructional factors.

A long term Strategy must be taken in consideration for the holistic approach to increase the green areas and support the sustainability which can solve many problem in different aspect an enhancing the quality of life physiological and physical.

Green roofs have the ability to reduce the energy consumption required as it provides a material and economic return and individual income it also Improves environmental problem like air pollutants, urban heat island effect, carbon emission in urban areas because plants act as natural air filters especially in slums which suffers from air pollution, solid waste, high temperature, high population density and lack of green spaces.

Recommendations

The recommendation are targeting architects, urban the government, investors, stakeholders, and all concerned authorities.

- 1) Architects should take into consideration all the procedures concerning green system that assure the conservation of energy and water resources on short-term and long-term plans and improve the mental health.
- 2) green roofs and farms and all topic concerning increasing green area space is recommended to be included in the academic design or landscape course content at not only in all architecture departments but also the supporting engineering disciplines.
- 3) Encouraging scientific researches related to sustainability and increasing the green areas approaches in order to develop cities and the community to reach more sustainable healthy city.
- 4) It is recommended that the local engineer's syndicate take the responsibility of making training courses and diplomas for raising the awareness of the engineers and architects with the critical role of green areas in sustainable design in achieving a healthy productive community.
- 5) Green walls, green roof, roof-top farm to be in the standard Egyptian building code for the existing or new buildings should, in order to minimize the long-term

expenses represented in the water and energy consumption.

6) Egyptian buildings should be regularly updated to catch the latest technologies related to irrigation systems or greening systems, as well as the sustainable design constraints and regulations.

7) It is recommended to raise the awareness of the risks resulting from global warming and green-house effect for the citizens and the sustainable development advantages

8) It is recommended to raise the awareness of the importance of increasing the green areas and their long term and short-term impacts on the development.

9) Funding form NGO'S organization for the sustainable development of the existing and new building based on the sustainable design standards for using green walls or green roofs.

10) Preparation of administrative leadership that understands the role of sustainable development on the quality of life.

11) Monitoring the maintenance processes for green areas and the buildings that have the green wall, green roof or rooftop farm, to prevent them from being a problem rather than as solution on the environment.

12) Setting strict legislation that must be followed for giving a license for new buildings with green walls or green roofs.

References

- Attia,S. & Mahmoud,A., (2009), Green Roofs in Cairo: A Holistic Approach for Healthy Productive Cities, *In Conference Proceeding on Greening Rooftops for Sustainable Communities, June 3-5, 2009, Atlanta, USA.*
- Nations, U. (2007). World Urbanization Prospects: The 2007 Revision Population Database. Online: Population Division Of the Department of Economic and Social Affairs [http //ww Kafafy, N.A., \(2010\). The dynamics of urban green space in an arid city; the case of Cairo- Egypt, Cardiff: Cardiff University- PhD Study.](http://www.kafafy.com)
- Gedge D., (2019). Living Roofs and walls from policy to practice 10 years of urban greening in London and beyond, livingroofs.org.
- Dunnett NP, Kingsbury N. (2004), *Planting Green Roofs and Living Walls*. Portland (OR): Timber Press.
- Scholz-Barth, K. (2001), Green Roofs: Storm water Management from the Top Down. *Environ. Des. Constr.* Feature January/February 2001.
- Luckett, K. (2013), *Green Roof Construction and Maintenance, A Gren Source Book*, <https://www.the-ies.org/analysis/role-trees-and-other-green>
- Green Roof Modular System, (2019), *Green Roof Modular System*, <http://www.green-urbanscape.com/en/solutions/green-roof-modular-system>
- Gawad,I.,(2015), The rise of rooftop gardens in informally developed area in Egypt: exploring the abilities and boundaries. Cairo, Cairo University.
- Fanger, O. (2013), *Thermal Comfort Analysis and Applications*. In *Environmental Engineering*, Krieger, Malabar, Fla. 1982, Vol. 0-89874, pp. 6