

البحث رقم (٩)

**Green roofs and their role in improving the shape of  
neglected areas**

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## ملخص البحث

مفهوم جديد ومرتل نسبياً لتحويل الأسطح التقليدية إلى أسطح خضراء؛ الذي يتضمن زراعة صغيرة وزراعة العشب فوق الأسطح في المناطق الحضرية لتبدو جديدة ومختلفة من الناحية الجمالية هو ما يسمى بمفهوم الأسطح الخضراء. تناقش هذه الدراسة البحثية مجموعة واسعة من المناخات وكيفية مراقبة تلك البيئات، مع تنفيذ الأسطح الخضراء وكذلك كيف يمكن أن تؤثر هذه الأسطح الخضراء على البيئة الحضرية والأماكن المزدهمة مثل المدن. هناك جوانب معينة من هذه الأسطح الخضراء في المناطق الحضرية التي تحتاج إلى التأكيد بشكل صحيح؛ الذي يتضمن ترشيح ملوثات الهواء في تلك المناطق المعنية، وإنتاج الأوكسجين الذي تشتد الحاجة إليه في المنطقة المعنية، وطريقة لتقليل فقد مياه الأمطار التي يتم تصريفها من أسطح الأسطح، والمساهمة في تقليل الحرارة الحضرية، وكذلك تحسين السطح العلوي الأسطح مما يساهم في تقليل الضوضاء وزيادة مساحة الغطاء النباتي. أكد هذا البحث شيئاً آخر وهو أن هناك ضرورة لإجراء أبحاث في هذا المجال لتحديد كيف يمكن لهذه الدوافع أن تؤثر على تحركات الأسطح الخضراء وكيف يمكن أن تغير البيئة في مراكز المدن أو في وسط المدينة. قد لا تكون النتائج متشابهة من مؤلفين مختلفين، لكن العوامل والدوافع الخاصة بتنمية حركة السقف الأخضر وتأثيرها على البيئة وأصحاب المنازل ستكون هي نفسها من كل مؤلف ومن كل دراسة بحثية. قدم هذا العمل البحثي أيضاً توصيات هيكلية لنماذج دراسة السقف الأخضر المستقبلية وكيف يمكنهم تطوير مستوى أبحاثهم في بدء هذه الحركة. كان الهدف الأساسي من هذا البحث هو تسليط الضوء على تأثير الأسطح الخضراء على البيئة في المناطق الحضرية لذلك، قد تكون هناك مساهمة إيجابية وبناءة في حركة السقف الأخضر.

## Abstract

A relatively new and improvised concept of transforming traditional roofs into green roofs, which involves mini plantation and growing of grass over roofs in urban areas to look fresh and aesthetically different is what is called green roofs concept. This research study discusses a wide variety of climates and how to monitor those environments, with the implementation of green roofs as well as, how these green roofs can impact urban environment and crowded places like cities. There are certain aspects of these green roofs in urban areas that needs to be properly emphasized, which involves filtration of air pollutants in those respective areas, oxygen production that is much needed in respective area, a way to reduce loss of rainwater discharged from roof surfaces, and contributing towards the reduction of urban heat, as well as, improving the roof top surfaces, contributing towards the noise reduction, and increase the vegetation area.

This research has affirmed another thing that there is a necessity to conduct researches in this domain to determine how these motives can impact green roofs movements and how it can transform the environment in city centers or in downtown. The results might not be similar from different authors, but the parameters and motives of growing this green roof movement and its impact on the environment and homeowners would be the same from every author and from every research study. This research work has also provided structural recommendations for the future green roof study models and how they can advance their level of research in getting this movement started. The basic aim behind this research was to highlight the influence and impact of green roofs on the environment in urban setups. So, there might be a positive and constructive contribution towards the green roof movement.

**Keywords:** green roofs, friendly environment, urban areas, urban heated areas, air pollution, rainwater, green roofs insulation, mini-plants, green roofs contributing towards fresh environment, noise reduction.

## 1. Introduction

Green roofs are a relatively new concept defined as a living system that is basically an extension of roofs. This green space can be either below a surface, at the surface, or above the surface involving settings or stockpiles where plants are not planted in the ground; but are grown in some sorts of little arrangements. This system requires a high-quality waterproofing membrane just to keep roofs safe and not pouring water and a root barrier system where the roots of the plants can be stopped, drainage system to stop drainage of water, filter fabric for plant coverage, a lightweight growing medium that can be uplifted of the roofs, and plants. These roof systems or arrangements can be grown in a layered systems that is prepared in trays, including drainage layers, growing media, that could be the clay, and plants, or all these components can be installed separately on top of these trays or other structures that hand them above roof.

Green roof plantations can be shallow that are also known as extensive, or deep type systems that are also known as intensive. Shallow types of green roofs have four to six inches of substrate in which plants can grow and might not support a wide variety of plant species because they have less room for the roots to grow. But the deep green roof systems are alike to gardens that have certain depth starting from six to eight inches and lasts up to several feet of growing material that might be clay and support a wide variety of plants. There are certain building types that are not so designed to hold or bear the additional weight of these deep type green roof systems. consulting a structural engineer

first in order to go for this idea and install any type of green roof should be done before starting any kind of green roof. Yet it is a good way of keeping gardening instincts alive and using spaces at roofs in a good manner (Tim Carter, 2008) (Figure 1).

There is a long history of green roofs

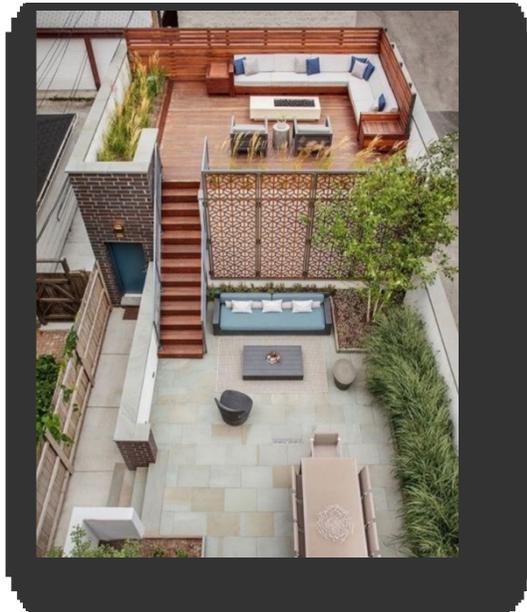


Figure 1. Green roof can help extend small spaces of flat/house

being used in Europe even for the decades but recently they are also being introduced in the temperate areas of the United States as well. Green roof designs, their settings, and how these are implemented in a limited setting is not yet entirely understood for the areas where water deficiency is at its best, areas like semi-arid and arid climates. Such an

area has low annual precipitation, low humidity, and high solar radiation due to being situated at high altitudes, high wind velocities and more often sunny days make growing of plants on the roofs more difficult so this needs to be more carefully chosen and techniques that suits these environments are to be implemented. With such an environment, some specific design strategies, specific sorts of plants, growing clay with different orientation and type and further irrigation requirements are needed to grow green roof projects. This could be the only way that it can evolve for semi-arid and arid west climates (Muhammad Shafique, 2020).

## ***2. Previous studies***

A research study conducted with the topic of analysis of the environmental benefits of green roofs, conducted by Umberto Berardi and his research fellows have discussed the implementations, technologies, and benefits of green roofs systems. While discussing the benefits, they have highlighted this being the way to reduce energy consumption, mitigation of urban heat island effect, improvement of air pollution, water management, increase of sound insulation, and ecological preservation. They have also discussed life-cycle cost of

green roofs and the policies made by government officials in promoting and supporting the green roofs worldwide (Umberto Berardi, 2014).

Another research study has discussed the effective factors that can reduce energy consumption in residential buildings with green roofs and is being discussed by Amir Hossein Refahi and his research fellow. This study has discussed amount of energy consumption and the possible way to reduce it could be the green roof systems. They called it the most effective approach. Their results have suggested that using green roof in Very Hot Dry, Warm Dry, and Mixed Dry climates will eventually have energy consumption decreased up to 8.5, 9.2 and 6.6 percent respectively (Amir Hossein Refahi, 2015).

Another research study conducted by Katia Perini and her research fellows have discussed either greening the buildings will be economically sustainable or not. They have used cost-benefit analysis to evaluate the advantages of vertical greening systems and green roof systems. They have combined both these systems including vertical greening system and green roof systems and installed it on an office building. They further evaluated the advantages and scope of both these systems.

The Cost-Benefit Analysis of these different combinations of vertical greening and green roofs have considered personal benefits and costs over their life cycle. Their results have shown that the tax incentives and the combination of both these systems can reduce the installation and maintenance costs and can make it economically sustainable (Katia Perini, 2016).

Another study conducted on the subject of quantitative study of cooling effect of green roofs in a high-density urban Area and was conducted by Jing Dong and his research fellows. This study has discussed an empirical analysis of cooling effects of city-scale green roof systems,

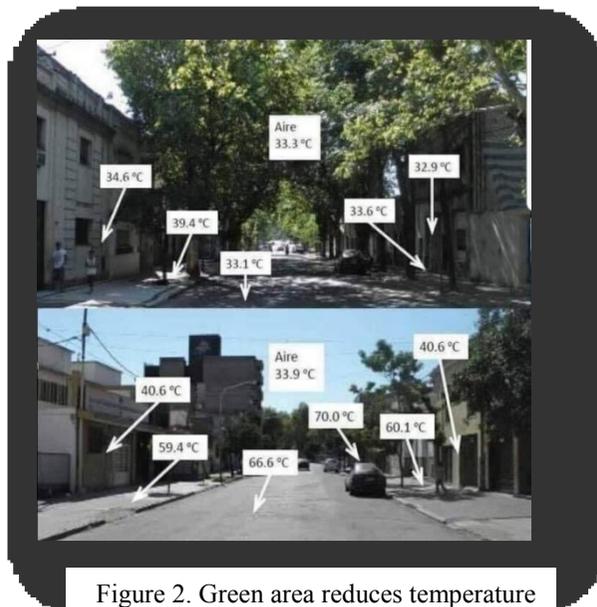


Figure 2. Green area reduces temperature

green roof system capable of reducing average land surface temperature difference by 0.91 °C overall. They have suggested that urban green roof systems could provide a cooling buffer of nearly 100 m. Green roof systems have a direct impact on the area and can cover within 100m buffer area to provide cooling effect. They have the potential to decrease temperature by 0.4 °C for every 1,000 m<sup>2</sup> increase in green roof area (Jing Dong, 2020) (Figure 2).

### 3. *Research methodology*

The idea and aim of this research were to discuss the orientation and enhancement of green roof systems; how they work, how they could be achieved in a limited environment, and how well they can be managed to alter severe environmental

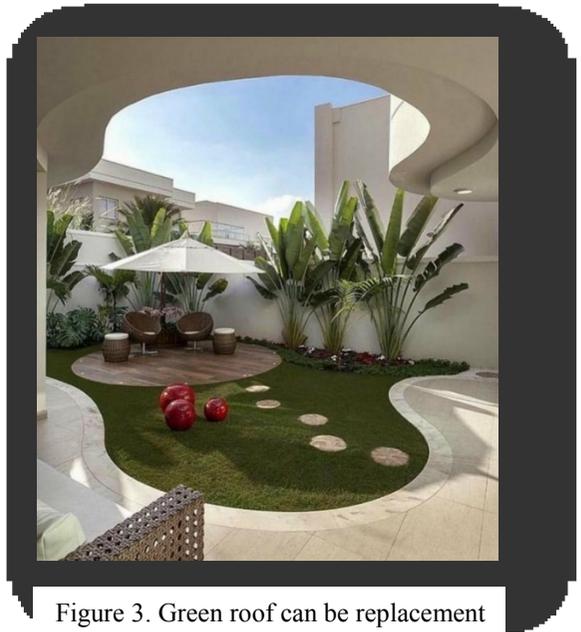


Figure 3. Green roof can be replacement for garden, courtyard, and private swimming pool

conditions. Another thing that is an alternative to this system is cool roof system (Figure 3).

Cool roof system prove to be an alternative option to green roof systems and these work for the reduction of heat. These types of roof systems are made with some reflective and emissive materials that will always remain cool even in peak temperature environments. Green roof systems require a large capital investment than it is required for the cool roof systems, but green roof systems offer a longer span of life than its counterpart. Both these systems are meant to reduce surface and air temperatures and will eventually decrease energy consumption.

But, in addition to this, green roof systems can offer other valuable benefits as well; including a filtration alternative for the storm water; absorbing and purifying pollutants from the air (Figure 4), could be a source of living for the natural habitat, and if you employ intensive green roof systems, it can serve as an easily available and

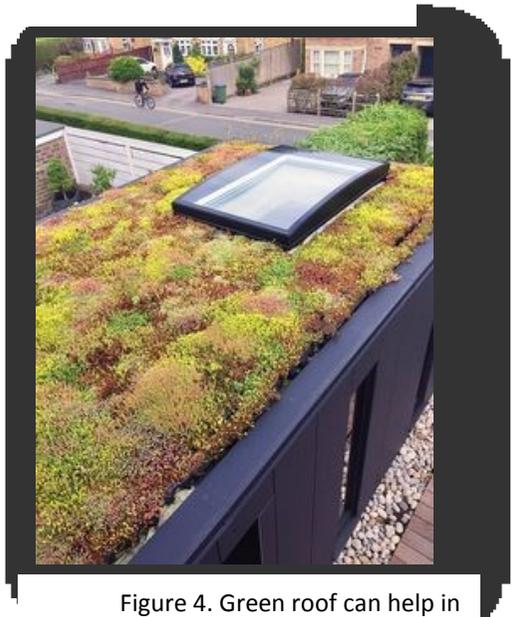


Figure 4. Green roof can help in cooling roofs and areas around it.

extensive green space; a plus point for environment. Cool roof systems could be the best decision if you have a limited budget timeline and your main concern is to work it out for energy savings, whereas, green roof systems is best for you if have a focus on public benefits and broad environmental impacts. Both these roof systems are mandatory strategies to overcome and lower the heat island effects.

#### 4. Green Roof Types

The first type of green roofs is Shallow green roof systems that are also called extensive green roofs. These roof systems might include tray systems which can grow medium plants, or small height plants, vegetables, and related other plants. These might be watered through simple watering methods and can grow medium plants and might include different thick layers of growing medium like clay. Their depth might vary around 4-6” and could be easily maintained. Keeping these shallow green roof systems alive in arid and barren areas might be a challenging task. One more thing, keeping diverse plants alive could also be difficult, but using some continuous laid systems might be helpful to grow diverse plant species (Figure 5).

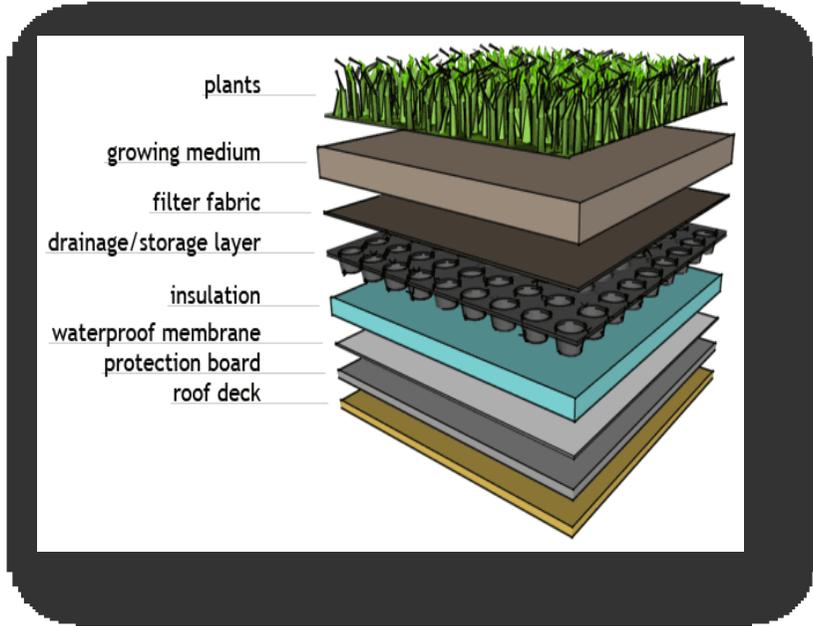


Figure 5. Green roof installation diagram

The weight of shallow green roofs would be between 15 to 55 lbs./square foot and some of its advantages might be that it carry low weight, require low maintenance and low irrigation, low monetary investment and could be suitable for large areas. They could easily be replaced and could prove to be profitable for households and environment (Kristin L. Getter, 2009).

The second type is of deeper green roof systems that are also called green roof gardens or intensive green roofs. These types of green roof systems vary according to their depth that might exceed 6-8” sometimes. These roof systems will allow more diverse nature plants and can carry heavier plants or extensive layers of growing medium.

Their weight might lie something in between 80 to 150+ lb. /square foot and will benefit you from the greater diversity of plants and biodiversity, water management with different ways and can also benefit with insulation properties, lovable and favorable design opportunities and higher chances of accessibility and daily use (Mark T. Simmons, 2008).

These two types of green roofs might look the same as according to their clay or growing material layering component and might vary according to the use of barriers that prevent water or root damage, another layer added that is called drainage layer to help setup in water drainage situation, and according to the growing medium as well. The Common Green Roof Layers type and intensive green roof setup could be seen in the figure. Most of these green roofs might vary according to the layers that will vary your green roof type and material used for layering.

#### **4.1 Advantages of Green roof systems**

Green roof systems look great, be an energy efficient source, and are environment friendly, so it can make better use of neglected and wasted

areas. For such type of roof systems, roofs are covered with plants, vegetation, and certain other decorative plant species. There are some positive and negative points as well for these systems that will be highlighted further in following paragraphs.

Green roof systems can help in improving the drainage system. Suitable and viable drainage system is mandatory requirement for any building. These are the only ways to mitigate flooding if it came across excess rainfall. Traditional ways include installing pipes that drain down the roof water to sewage system. However, due to an ever-increasing urban development, estimates show that 75% of water is running off into urban areas and not absorbing down to the earth. Global warming isn't helping at all in such a drastic situation and risk of continuous flooding has gone high throughout the entire world. To counter this threat, green roofs are the best alternative. Water could be absorbed into the plants before being released back into the environment naturally.

Green roof systems can help in increasing the lifespan of the roofs. A rooftop could be prevented from certain environmental effects and attacks and could be the way to recycle water back into the atmosphere.

These are not the only curses for the roofs but they also have to deal with wind and rain, ultraviolet rays, and fluctuating temperatures as well. So, this is now becoming a common exercise of both homeowners and businesses to go for alternative options to save their roof tops. Green roofs have the potential to offer much and possess a longer span of life expectancy. This greenery barrier will help in protecting the waterproof membrane and ensure a longer lifetime for rooftop that might prevail until decades.

Green roof systems can help in boosting thermal performance. One of the biggest problems of typical roof systems is lack in provision of sufficient

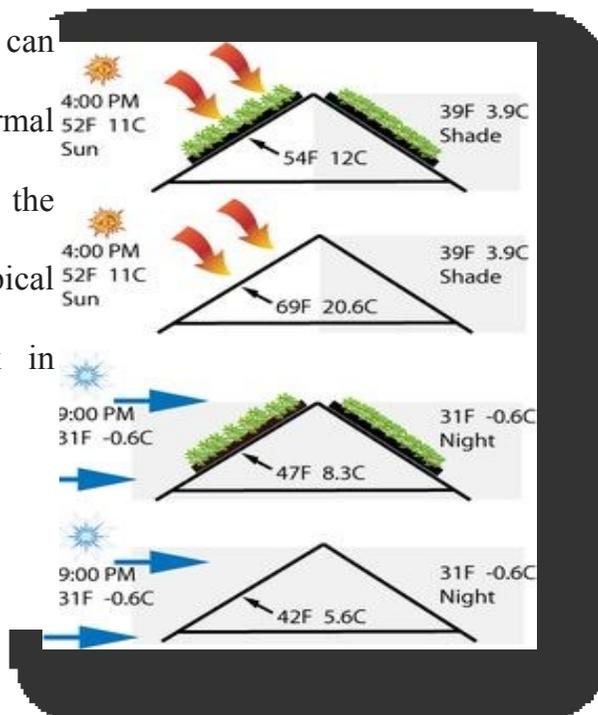


Figure 6. Green roofs slow absorption and release heat sinks

insulation that will lead to more heat loss in winter and unfavorable conditions over the entire summertime. This could be tackled well with green roof systems. \, the governments have been made accountable to meet those protocol targets by 2020. Green roofs are the best way to do so. According to analytics, 44% of total CO2 emissions are released from buildings. Green roofs have the potential to reduce air conditioning, as well as ensuring less heat requirements for the winter time (Amir Hossein Refahi, 2015).

Green roof systems can **support wildlife** as well with their existence. This way, these can create a healthy habitat for different species. These might not have direct interaction with the ground environments, yet they can attract birds and other wildlife species to create a thriving eco-friendly environment. Every type of green roof will support certain species depending on what has been cultivated. According to a study done in Switzerland, they have studied 11 different green rooftops and found 172 different and viable species depending and living on green roof systems (Umberto Berardi, 2014).

Green roof systems can help in improving air quality as it is discussed earlier in this section. Air pollution is a devastating issue around the

globe. A research study has found that around 24,000 people die in UK alone from this factor every year. That cause is a serious threat in urban areas, especially in the larger cities around the globe. A green roof systems is meant to provide help in improvement of the overall air quality index. These roof systems have the potential to help reduce 37% of sulfur dioxide production, 21% of nitrous acid production from pollutants, and 0.2kg of dust particles / square meter each year.

#### **4.2 Disadvantages of Green roof systems**

Setting aside these benefits of green roof systems, there are certain drawbacks as well that need your attention before making an investment.

Green roof incurs **a lot of expense** than traditional roofs. Green roof systems are considered to be slightly expensive than the traditional roof systems. The reasons behind all this is that it requires a large support mechanism to handle the increased load. However, despite this economic disadvantage, green roofs can cover up a lot that it can outcry this drawback. If you consider benefits of this roof system highlighted

above, you won't hesitate in allowing this cost to play a determining role within your environment (Katia Perini, 2016).

With a lot of support mechanisms, there comes an increase weight load over your roof. So, you might also have to tackle with it. Green roof systems prove to be much heavier and will require some structural and firm support before their installation. adding green roof system on rooftop, it will add between 50 and 200kg/meter squared to the existing load. Although there are certain ways to reduce load and evenly divide over the support to cope with the increase in load, but you need to have a flat rooftop to handle this load capacity.

Green roof systems will require timely and extra maintenance. So this will also incur some cost to pocket. There is a lot of debate over this aspect in the recent past but the fact is you need to do a lot of maintenance to maintain its viability and beauty, you need to do a lot of work to ensure the thriving atmosphere situation. You need to treat your green roof as a garden and requires continuous watering, feeding and weeding. You can do this by yourself or can employ someone to take care of this thing. Either way, it would be great to keep on top of this brilliant green area.

### **4.3 Estimates of environmental effects**

Once a study of EPA published discussing a case study of green roofs, which was about estimating the environmental effects of green roofs and discussing their environmental and health advantages. They have used multiple tools that are already used by the state and local decision-makers to assess the benefits of green roof systems. This study has found that the over 700,000 square-foot total coverage of green roofs is done in Kansas City during the period of 1999 and 2020 and this has resulted in avoiding emissions of 384 pounds of nitrogen oxide, lowering a staggering 734 pounds of sulfur dioxide, and 269 tons of carbon dioxide, alone in 2020. These emissions reductions can provide a monetary health benefit of around \$35,500–\$80,500.

## **5. State of Kuwait Roofs**

Due to Kuwait's location in the desert geographical region, its climate is of a continental type, characterized by long, hot, dry summers, and short warm winters that are sometimes rainy. Dusty winds blow during the summer months, and the humidity rises during the mentioned months, and the temperature may sometimes reach 50 degrees Celsius in the summer months. Shade, often with dusty winds (dust storms). As

for the winter season, despite its shortness, it is warm, as the average temperature during it reaches 18 degrees Celsius, and the temperature may drop to zero degrees Celsius in some cases. As for the fall and spring seasons, they are characterized by their palaces. Winter rains are unpredictable and differs from year to year. Because of that climate, Kuwaiti citizens refuse - for now- using roofs for any activity (Figure 7) except for take advantage of the roof space of their house to keep the air conditioning system is called "RV" - the flow of variable coolant (Figure ٨).

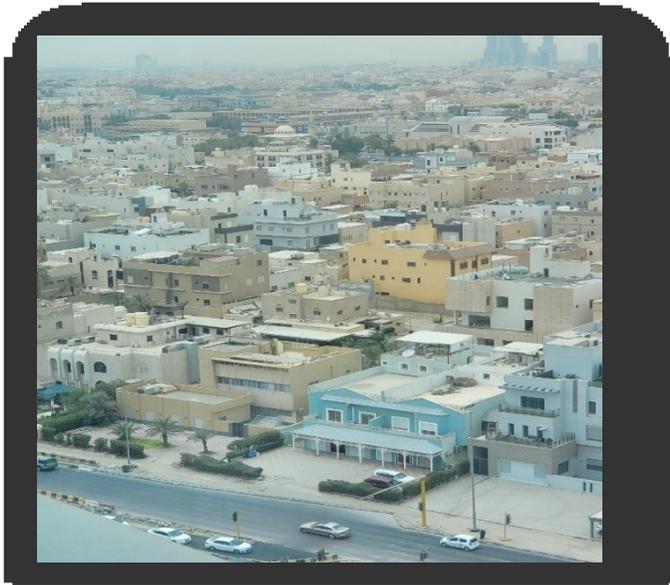


Figure 7 . Wasted area of roofs can solve space /reduce surrounding area heat/ clear air/ green areas – Hawalli, Kuwait- photographed by the researcher



Figure 8. Air conditioning system on roofs in Kuwait

## Survey results

A questionnaire was distributed made by the researcher and sent by e-mail to a number of 1500 Kuwaiti citizens, only 943 houseowners had replied with number 568 male, and 375 females randomly selected from different governorates of Kuwait (Figure 9 A, B).

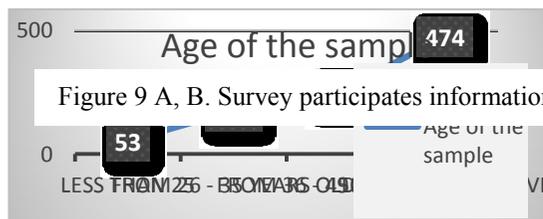
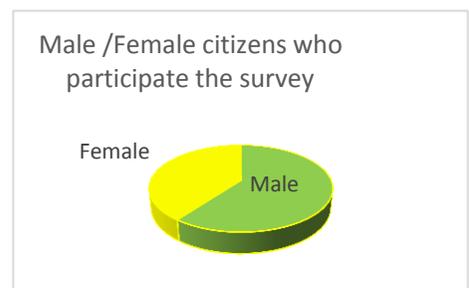
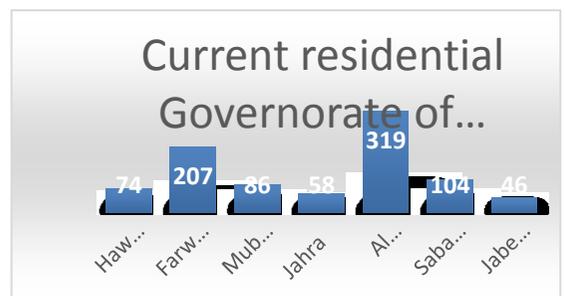


Figure 9 C. Chart shows the age of the chosen sample

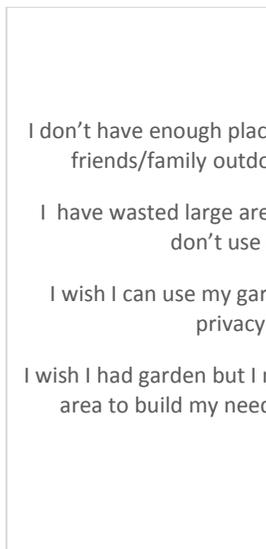


Figure 10. Chart of the Citizens response

There was four main questions been asked the citizens to understand their point of view about their roofs. The first question was if they have enough space for gathering friends or family members in outdoor activity, As it shown above in the chart (Figure 10), the Females were the highest response about not having enough place for outdoor gathering, comparing to the response of Males which been the lowest demand of that, being the nature of Males don't spend much time inside houses comparing to females, so they don't feel those differences as much as females. The second question, also the female response higher than male in the question if they have area wasted on

their roof. In the third question, it asks houseowners if they had enough privacy in their present gardens (which locates Infront the house in ground floor) as an Islamic Arabic society as Kuwait, privacy means a lot for households especially females, so as shown also in this question the response of females was higher than males. In the fourth question, the question ask houseowners if they prefer garden or using its space to build something more important because of modern houses became smaller, the houseowners build most of the provided area to fulfil his needs of rooms instead of wasting it on garden as some citizens responses although it was a wish for them to had one.

Here, we can see that the alternative is using roof as garden, gathering area, swimming pool, and other activity can be done in this wasted area.

## 5. Conclusion

Concluding the remarks of other authors and work of this study, there has been a valuable increase in the number of buildings equipped with green roofs in urban settings and are contributing towards the increase of biologically ready and



Figure 11. Saudi house roof before & after green roof.

ever green areas and lowers the average temperature of the area. This will in turn lower the effects of the urban heat island and will advocate the benefits of green roof systems (Figure 11).

The high efficiency provided by the green roof systems will act as an insulating layer for heat or rising temperatures, humidity, decrease dust, and rising aspects of the building could also be verified and demonstrated. Majority of the published research works have ensured the potential of green roofs for reduction and sequestration of CO<sub>2</sub>, NO<sub>x</sub>, SO<sub>2</sub>, and heavy metals in plants and growing material like clay.

The positive impact or positives of green roof systems could also be ensured or verified due to the reduction of the rainwater drainage from roof surfaces.

This could be the reason that most publications are proved by the laboratory tests or experiments that are carried out on existing green roof systems, the results of these tests have reflected the impact on the environment due to the green roof systems in specific climatic conditions and a location of research facilities. The results obtained from different studies conducted in South-East Asia or in the Southern United States regions might not be the same as were shown in the Central and Eastern Europe areas.

The literature from different studies have shown a plan to devise some valuable research plans, which might consider some methodologies used by other researchers and scientists while doing their research done in temperate climates. The research on these issues and paraphrases have helped in formulating a model that defines the following including reduction of gaseous pollutants, reduction of the heat effect or temperatures, as well as, sustainable rainwater management based on where the green roofs are installed within the city. This model is

devised with enough plan that it will facilitate the process of devising it though the area to improve air quality index in urban areas. done before starting any kind of green roof. Yet it is a good way of keeping gardening instincts.

The researcher suggests that green roofs should be used on the roofs of government buildings, mosques and hospitals to be used first for the experiment and then generalized to the rest of the buildings if they prove their success, especially in improving the environment around them and as a contribution to reducing temperatures and improving air quality.

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