Greenery in Cities and Controlling the Reasons of Urban Heat Islands – a Sustainable Approach for the Spaces of the Future in Controlling Urban Heat Islands

Islam Elghonaimy, Dalia Eldardiry

(Associate Professor of Architecture Islam Elghonaimy, University of Bahrain, Bahrain, eelghonaimy@uob.edu.bh)
(Associate Professor of Architecture Dalia Eldardiry, Imam Abdularahman Bin Faisal University, deldardiry@iau.edu.bh)

1 ABSTRACT

Amid the current global climate change, countries are facing a critical challenge in consideration of dealing with its consequences. In Bahrain, the urbanization process has been of grave consequences upon the urban open spaces quality. Therefore, a low percentage of vegetation and "CONCRETE FORESTS" occurred, which acts as heat absorbents towards the building' inner spaces. Consequently, overpriced monthly electrical bills were resulted due to the excessive energy consumption in cooling the building. Furthermore, these cement blocks emit heat towards the surrounding urban spaces, deteriorating the urban quality of the city. Lamentably, these factors have released socio-economic and environmentally unsustainable perception of cities in Bahrain.

In the old part of Manama city, the capital of Bahrain, we find this problem very clear. According to the field survey, most of these buildings' facades either have no or minor climatic treatments. Paints and lesser types of thermal insulation; as well as; using natural materials in building blocks is the existing treatment-seeking least insulation impacts. The research presents the green walls upon buildings' facades as a cooling method of the interior spaces during summer and for a thermal insulation technique as well. This technique will add value in controlling the reasons of the Urban Heat Island (UHI) and overcoming as well in Bahrain.

Keywords: Concrete forests, Living green walls, Sustainability, Urban heat island (UHI), Urbanization.

2 INTRODUCTION

Most of the cities in the Middle East and North Africa (MENA cities) in general and Gulf cities in particular, the cap face a dramatic increase in the grave consequences of climate changes problems. (Guzmán et al., 2009). Urban designers, landscape architects, and architects have their responsibility towards creating different solutions in overcoming these dramatic climate changes problems. Unfortunately, there is a lack of coordination and integration between the work of the specialists and the professional discipliners primitively in mainstream climate change problems in the local, regional and international levels. UHI is one of the results of these miss coordination between the urbanists as well.

The old urban areas of the kingdom of Bahrain' suffer from the rapid changing in the urban pattern and its characteristics, which occurred in conjunction way with a shortage of open spaces and greenery. Some urban ideas moved toward adopting vertical urban expansion (Figure 1) (El-Ghonaimy and Javed, 2018). In the same issues, Unfortunately, most of the facades of the existing building in the old part of Manama city are vulnerable to heat, warming, and traversing heat towards inner spaces with minor thermal treatments. Moreover, it is challenging to deal with the existing building facades in term of insulation systems. Therefore, the installing of the Green vertical wall is suitable, as an envelope for existing old buildings that is does not need to change the wall; it is just adding layers with proper fixing.

From the planning point of view, many infrastructure plants that generate energy and electricity that suites the urbanisation needs were constructed. Also, water and sewer treatments plants were rapidly built to support urbanization progress. It should be noted that Bahrain depends on the use of the country non-renewable-resources such as the fuel fuels in generating energy, which mainly directing towards use in Cooling buildings, especially during the summertime. All the previous conditions rose the reasons for happening the urban heat islands (UHI), where the urban settlement demonstrates a higher temperature in some places than the surrounding area (Nuruzzaman, 2015). Moreover, a pilot field study by the researchers indicated the happing of the UHI in Manama city, the capital of Bahrain. Since UHI phenomena threaten Bahrain, a critical question appeared as the focal point of the research, which is: how can Bahrain control and limit the accruing of UHI? Answering this question will be the scenario of this research. Therefore, the research focuses on presenting one of the useful and practical technical solutions that will help in controlling this phenomenon in the Kingdom of Bahrain.

ISBN 978-3-9504173-8-8 (CD), 978-3-9504173-9-5 (print)
Editors: Manfred SCHRENK, Vasily V. POPOVICH, Peter ZEILE, Pietro ELISEI, Clemens BEYER, Judith RYSER, Christa REICHER, Canan ÇELIK

Fig. 1 (left(: Bahrain is an island, has limitations of land for horizontal urban growth (Al Aali, 2008). Fig. 2 (right): High-rise building (concrete forest) with a low solid/void land uses ratio within the Manama City urban' pattern (researcher, 2019).

Thus, research illustrates the concept is to have greenery upon wall functioning as an environmental temperature insulation layer, preventing the summer burning heat from affecting the exterior structure of the building, and trespassing them their interior spaces; as applied in many Gulf Cooperation Council (GCC) cities such as Dubai and Abu-Dhabi. Also, this technique serves the ongoing economic growth and nurture the national income by creating many job opportunities for the unemployed. Furthermore, the ripe unique collection of plants could be either sold for a decent monetary value or get locally utilized for nutrition security and self-sufficiency purposes. Mainly, concerning this system is recommended, especially in case the difficulty in doing indoor thermal treatments (planters, 2018).

In sequance, the research methodology was divided into the following parts:

- Literature review: about UHI
- UHI in Manama city and its locations.
- Analyzing the urban pattern and building facades.
- Proposing the method for controlling UHI in old Manama.

3 THE PHENOMENON OF UHI

UHI is an area that is hotter than the surrounding because of a climate phenomenon. In other words, UHI is a climate phenomenon that results in increased air temperature in cities, when compared to their rural surroundings. (Sobstyl et al., 2018). Due to the rapid urban growth in cities, energy consumption is in the continuous increase, to match the accelerated needs for the metropolitan requirements. Accommodating the massive influx of people, cities will have to get smarter concerning sustainability and for the technical solutions towards energy preservation by scrutinizing every architecture detail (Martin, 2019).

Scientists have studied UHI effects for decades and the significant reasons for increasing this phenomenon in cities. Generally, these urbanisation progresses increased the demand for urban services and infrastructure plants. Moreover, it increases the urban problems within the city neighborhood districts in term deteriorating the urban pattern, neighborhood quality of life, and increase the environmental problems. The losing open spaces, high rise buildings, inappropriate insulation material or the absence of thermal treatments for building facades increase the temperature within the premises as well. Consequently, the demand upon using artificial air-conditions has accelerating, which increases the energy consumption within these areas (Elghonaimy and Elghonaimy, 2017). Therein, the UHI effects can also experience the increase of heatwaves, heat-related illness, air pollution and an upsurge in energy use (Henninger et al., 2015).

Furthermore, in ISESCO Journal for Science and Technology, has cited that the GCC countries are struggling on the horns of the dilemma; high-energy consumption out of the rapid population increase and its subsequent environmental threats, thanks to the high wave of modernization and astounding economic

growth. Logically speaking, the witnessed GCC renaissance has scored the top six CO2 emission rates all over the world, resulting in drastic climatic changes (Darwish, 2016)

4 REASONS OF THE PHENOMENON OF UHI

In recent years, the subject of the impacts of the "Climate Change" and the Phenomenon of UHI has been one of the critical issues on international political agendas, with significant economic consequences. Many scientific projects, research projects and academic reports, searched about UHI phenomenon. The drastic economic changes that occurred in Bahrain had a significant influence on the urban pattern and the architecture of the Island. The changing in the urban settlement can be noticed by the dramatical increase of the urban encroachment from 1990 to 2013. The growth did not occur in uniformity, and most of were focused on Manama (Wolfinbarger et al., 2014). In 2018, the land area for Bahrain was 778 sq. Km. It increased from 690 sq. Km in 1969 to 778 sq. Km. In 2018, the growth was at an average annual rate of 0.25%. The Agricultural land area was 86 sq. Km and Forest, which were about 11.1% and 0/8% of the share of land area (knoema, 2018b). Manama in Figures 3a shows that the original urban area was greeneries years ago. The roads were conforming to the direction of the sea breeze. Meanwhile, it went fewer greeneries farther from the Seaside. However, the new planning scheme complies with the city and its organic nature, which has changed to the more organized and modern. In the past, houses were fewer numbers in the urban context. The street network paved by natural stones (not asphalt) also the orientation of buildings was to take advantage of the wind movement, avoiding the direct exposure to the sunrays. Therefore, it created a comfortable environment for inhabitants to perform their daily activities. In contradict in figure 3b; recently, the city has rapid population increases and change in the urban pattern (Figure 4) due to the appearing of concrete forests, which became the domain. Streets became wider and paved with asphalt (heat reservoir) as well re-using the vacant lands and the open spaces towards buildings, which decrease the ratio of the vegetation in the area and led to deteriorating the quality of life for inhabitants.

Fig. 3 (left): Urbanization developing in the study area 1990–2013 (Wolfinbarger et al., 2014). Fig. 4 (right): The Changing in streets pavements characteristics in Bahrain: In old district: the use of traditional and natural pavements materials (researcher).

4.1 Developing projects and the increase of CO2 emissions

Massive, developing projects have been constructed to satisfy the population needs. These developing projects need more energy, especially for cooling in hot, humid days, which annually extend from the beginning of April to end of October. It is considered that more than 70% of year time, it is expecting to need for the massive amount of fossil fuels, to cool these buildings, by operating the power plants to generate the required electricity. The Carbon Dioxide Information Analysis Center “indexmundi” (2018) measurements show that the value for CO2 emissions from gaseous fuel consumption (kt) in Bahrain was 28,375.25 as of 2014. As the graph below shows, over the past 54 years, this indicator reached a maximum value of 28,375.25 in 2014 and a minimum amount of 0.00 in 1960 (Figure 5).

According to IEA Statistics (OECD/IEA 2014), it was calculated that the CO2 emissions from the different types of buildings (residential buildings, commercial ...etc.) and public services (% of total fuel combustion) in Bahrain were 0.84% as of 2014. The highest value over the past 43 years was 2.08% in 1998, while its lowest cost was 0.79% in 1974. The CO2 emissions from residential buildings and commercial and public services contain all emissions from fuel combustion in households (knoema, 2018c) (Figure 6).

ISBN 978-3-9504173-8-8 (CD), 978-3-9504173-9-5 (print)
Editors: Manfred SCHRENK, Vasily V. POPOVICH, Peter ZEILE, Pietro ELISEI, Clemens BEYER, Judith RYSER, Christa REICHER, Canan ÇELIK

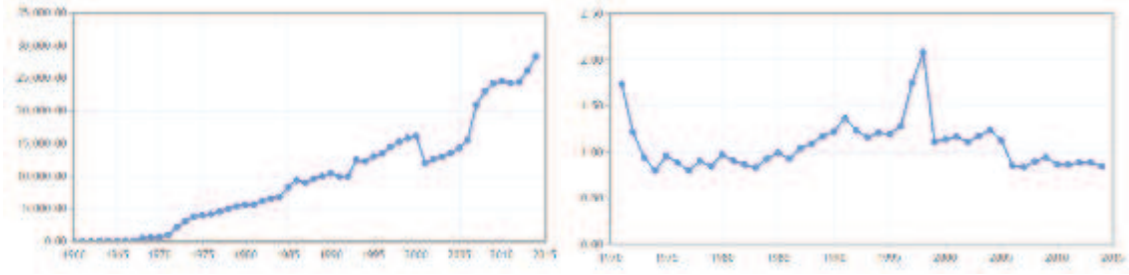


Fig. 5 (left): CO2 emissions from gaseous fuel consumption (kt) between 1960 and 2015 (indexmundi, 2018). Fig. 6 (right): CO2 emissions from residential buildings and commercial and public services (% of total fuel combustion) (indexmundi, 2018)

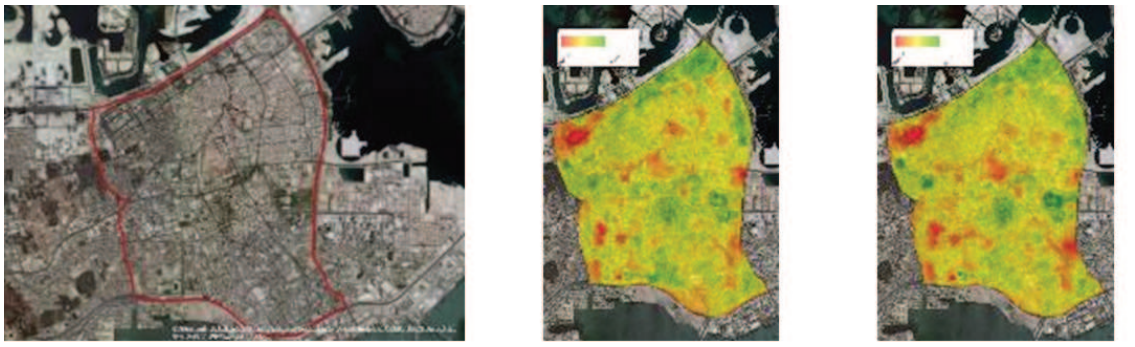
Indexmundi (2018) shows in a study in Bahrain, CO2 emissions increased from 14,658.3 kt in 1997 to 24,458.4 kt in 2016, growing at an average annual rate of 2.92 %. Moreover, the low greenery rate deteriorates urban quality in Bahrain. Consequently, the resulted problems from the UHI phenomenon are in increasing in old neighborhoods in Bahrain. Moreover, it should be noted there is increasing in the activities of the potable water plants (treatment – desalination) for supplying the urbanization projects must cope with such services, especially in cooling of buildings.

5 BAHRAIN NATIONAL STRATEGY 2030 AND UHI PHENOMENON

Statistic by Carbon Dioxide Information Analysis Center showed that Bahrain has the position of 42 levels between 117 countries with Value of 28,375.25 kt. It indicates the hazard level of CO2. (indexmundi, 2018). Unfortunately, the Strategy of Bahrain 2030 did not take serious actions in consideration the warning of the CO2 threshold. Nonetheless, the main aims of the strategy mentioned to re-establish the Bahraini Kingdom as an ideal island of living to the diversity of groups (SOM Consultancy Project for Bahrain, 2007).

5.1 Urban solid and void in old Manama

Elghonaimy and Mohamed (2019), in a research project about solid and void in urban of Manama Governorate, the considerable difference ratio between the built-up areas related to the vacant spaces have been revealed. The research has unearthed the concentration of huge buildings "Concrete Forest" with an apparent shortage of greenery inside the residential areas. The conducted practical survey and analysis in this research concerning Manama (Figure 8a) has concluded that the city suffers from the absence of appropriate urban open spaces and foliage in various areas of the city.



a. Pilot study map

b.Land surface temperature (LST) over Manama City in the Winter of 2017.

c. LST over Manama City in the summer of 2018

Fig. 7: Pilot study, UHI in Old Manama location in Capital Governorate, Bahrain in 2018 (researcher).

Most of the urban pattern has turned in to “Concrete Forest” with a shortage of greenery. This leads to the accelerating emergence of UHI phenomenon. Figure (8 b and c) shows the UHI in the old part of Manama city and the prevalence of UHI, out of the shortage of open spaces and greenery in these areas. In the same sequence, the CO2 emissions increased from 14,658.3 kt in 1997 to 24,458.4 kt in 2016, growing at an average annual rate of 2.92 % as shown in indexmundi (2018). In Bahrain, Moreover, the low greenery rate deteriorates urban quality in Bahrain. Consequently, the resulted problems from UHI phenomenon are in increasing in Bahrain. Moreover, it should be noted there is increasing in the activities of the potable water plants (treatment – desalination) for supplying the urbanization projects must cope with such services especially in cooling of buildings

5.2 Facade conditions in the Building

Infringing the stipulated urban rules of thermal insulation, in particular, ends up in an economic burden on the environment. Likewise, the number of heat reflecting facades and human activities are affected. Moreover, the lack of open spaces, large concrete forest areas and adapted facades types are cardinal factors in the mutual problem in the old districts in these cities. etc., causing the spread of the UHI. From the site inventory and analyzing the urban changes in Bahrain, it was noted that after the wave of modernization, the urban pattern had undergone several transitional phases. In the traditional city of Manama, one can notice in the old neighborhoods low-rise buildings, whereas, in other areas, they are modernly styled mid-rise buildings. Moreover, the city also contains high-rise towers of modernized glass facade in the eastern part. Additionally, most of the facades had a low level of thermal insulation for a long time. The governmental housing projects, which scattered in Bahrain, missed the prober thermal insulation and influenced the increase of the energy for buildings' cooling, which will explain in the next section. (Figure 9).

5.3 The resulted accelerating of Energy consumption in Bahrain

Unfortunately, the implementing process of the urbanization projects has no comprehensive defensive strategies against the UHI phenomenon. Therefore, there is a vast wasting of energy in services; such as cooling, supplying potable water and electricity. Bahrain can partly provide itself with self-produced energy. The most critical measurement is the total consumption of 26.09 billion kWh of electric power/year. Per capita, this is an average of 17,480 kWh. The production is 17 bn kWh from all-electric energy-producing facilities. That is 65% of Bahrain own usage. The rest of the needed power is imported from the surrounding countries in the Gulf region. The different energy sources, such as natural gas or crude oil, are also used (Table 1).

Electricity	**Total**	**Bahrain (per capita)**
Own consumption	26.09 bn kWh	17,479.75 kWh
Production	17.07 bn kWh	11,436.54 kWh
Import	205.00 m kWh	137.35 kWh
Export	213.00 m kWh	142.71 kWh
Crude Oil	**Barrel**	**Bahrain (per capita)**
Production	44,240.00 bbl	0.030 bbl
Import	223,900.00 bbl	0.150 bbl
Export	225,000.00 bbl	0.151 bbl
Natural Gas	**Cubic meters**	**Bahrain (per capita)**
Own consumption	15.50 bn m³	10,384.68 m³
Production	21.07 bn m³	14,116.46 m³

Table 1: Energy Balance. Source: https://www.worlddata.info/asia/bahrain/energy-consumption.php.

6 GREEN WALL SIGNIFICANT

Green walls, it is not the latest design fad. The concept dates back to the 1930s, and they are science fiction made fact. Many of the architectural companies trying to win design awards, of all sizes looking to improve their green credentials. Therefore, it is important to define the term of "green walls" which are panels of plants, grown vertically using hydroponics, on structures that can be either free-standing or attached to walls. Living green walls are also referred to as vertical gardens, living green wall, green walls, living walls or eco walls (Ambius, 2019). It is partially or wholly covered with vegetation and, in some cases, soil or an inorganic growing medium (Figure 11). The succession of the green wall is due to proper insulating, lightweight; choosing locally sourced plants would flourish all year round moreover it should be low maintenance as well as having internal irrigation system, which should be particularly beneficial as local staff can easily look after walls (Ansglobal, 2019).

ISBN 978-3-9504173-8-8 (CD), 978-3-9504173-9-5 (print)
Editors: Manfred SCHRENK, Vasily V. POPOVICH, Peter ZEILE, Pietro ELISEI, Clemens BEYER, Judith RYSER, Christa REICHER, Canan ÇELIK

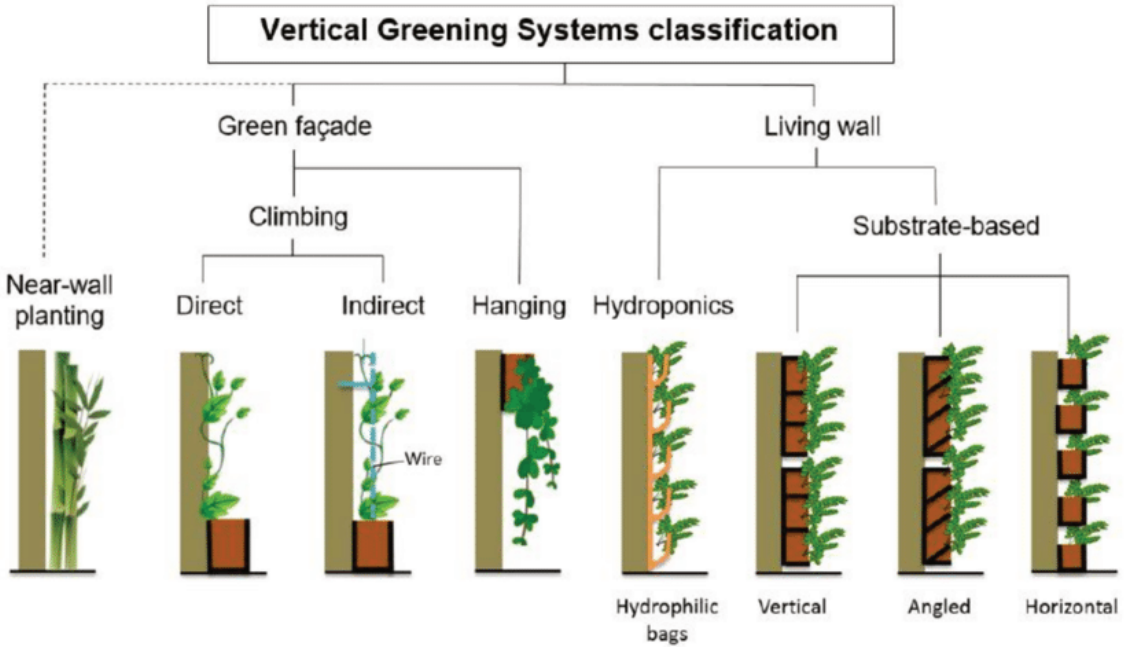


Figure 9: Vertical Greenery Systems classification. (Ottelle, 2011)

Discussing the significance of green wall in controlling UHI will be illustrated based on the fieldwork and the researches, as follows:

6.1 Energy impact of using green wall

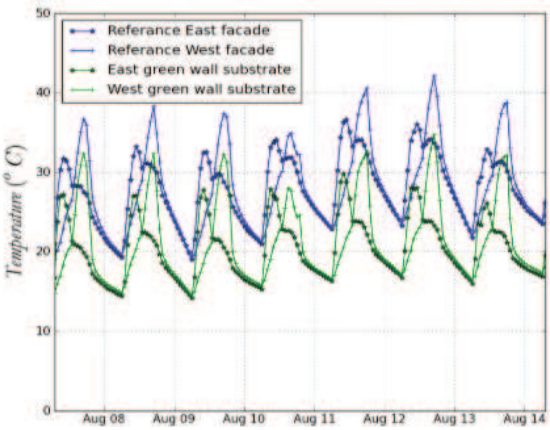
6.1.1 Energy saving

Green walls improve building energy efficiency by reducing energy cost. It enhances the building's thermal insulation by adding a protective layer of plants as well as the shading, and the evapotranspiration of the plants contribute to lower surface temperatures, and thus to reduce heat gains through the facades, which are also moderated by the large heat capacity of the plants (Henninger et al., 2015). Abdelsalam in his study, he concluded that comparing greenery in building upon facades to the standard walls, shows that the energy-saving up to 15%-32% depending on the thickness and thermal conductivity of the green wall composition (Abdelsalam, 2012).

Region	Season	Observation
Tehran, Iran	Dry-summer subtropical	Average air temperature above the green roof was 3.06–3.7°C cooler than that of the reference roof (Moghbel and Erfanian Salim, 2017)
Singapore	Hot-humid	Large urban parks significantly mitigated the UHI effect (Forsyth et al., 2005)
Florida, United States	Humid-subtropical	Lower air temperature under the shade of the trees compared to the surrounding areas (Sonne and Vieira, 2000)

Table 2: The effect of greenery on cites with similar climates to Bahrain.

A study by Djedjig et al. investigated the impact of the green wall on buildings energy demand as the more heat the building isolates the less energy it would require cooling itself. Two identical three-story buildings were covered by green wall on the east and west facade. One building is on La Rochelle, where the climate is similar to Bahrain. Building' walls were made of 20 cm cinder block and the roof made of 12 cm concrete. The green walls substrate depth is 12 cm, and its saturation ratio is fixed 60%. The vegetation coverage was kept constant. The results show that green walls reduced the temperature up to 10 degrees Celsius.



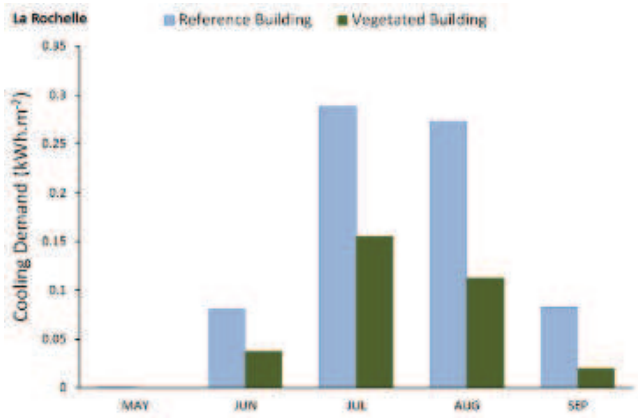


Fig. 10 (left): A diagram showing the temperature with and without a green wall (Djedjig et al.). Fig. 11 (right): A diagram showing the cooling demand with and without a green wall for La Rochelle (USA)

Furthermore, the vegetated buildings have less than half the cooling load of the reference building' Green walls reduce the temperature of a building by decreasing the U-value of the building envelope. Furthermore, the shading and evapotranspiration process lower the external temperature. (Djedjig et al.) Figures 12&13 show the results of the studies.

6.1.2 Energy cost reduction

It is propitious in saving energy up to 33% in countries with hot, humid climate; such as Bahrain (Payne et al., 2007). Consequently, it will reduce the budget of cooling buildings consumption and accordingly the annual amount of fossil fuels in operating the electrical, desalination water plants, which would end up in positive results regarding the energy cost reduction by reducing the consumption of energy in running artificial air conditions. Moreover, Al-Nuaimi and Khamis (2014) in a study on obtaining the advantage of the age of foliage in different places in some buildings in Bahrain, it was deduced that up to 68KWH of the annual energy consumption is reduced, saving about 150,321.6 BD.

6.1.3 Decrease the load from the power station

The governmental power station will not be loaded; especially in the summertime with the increase of building cooling purposes.

- Sound reduction

A study by Wong et al. (2010) was conducted to determine the noise absorption rate when green walls are used. Ferns were used for the green wall. Three sample green walls were obtained, one covering only 43% of the wall, the other covering 71% of the wall and the last one covering 100% of the wall. The results show that the thicker the green wall, the more sound it isolates. We can see that for sound frequencies less than 800 Hz even limited coverage of vegetation equally help with noise isolation. (Figure 14) (Wong et al. 2010)

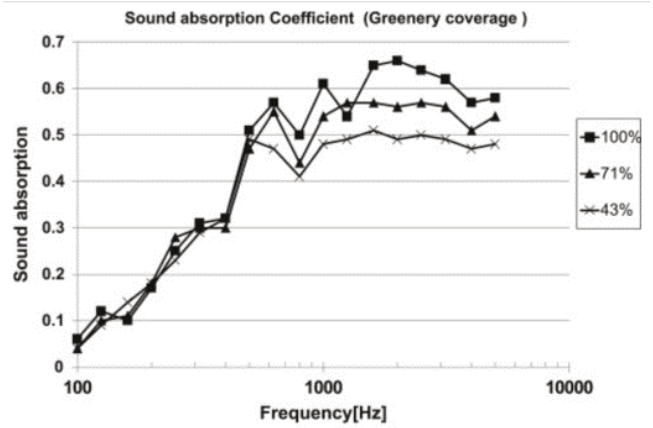


Figure 12: The amount of sound absorption in respect to the amount of plant coverage of the green wall and sound frequency.

- Marketing potential and Tenants' Economic Resources

ISBN 978-3-9504173-8-8 (CD), 978-3-9504173-9-5 (print)
Editors: Manfred SCHRENK, Vasily V. POPOVICH, Peter ZEILE, Pietro ELISEI, Clemens BEYER, Judith RYSER, Christa REICHER, Canan ÇELIK

Green walls are innovative design technique. The attractive appeal of living walls fascinates people, bestowing uniqueness to these buildings to be a distinguishing factor for marketing initiative (and romeda district, 2007). This would result in the tenants' financial welfare, for their owned buildings would be a productive environment with fruits, vegetables or flowers.

6.1.4 Nutrition security suppliers

Being a productive environment implies being a nutrition supplier to secure the residents' needs.

6.1.5 Psychological sequels

Bahraini citizens sanctify their privacy rights. It is represented in craving for separate independent housing units. Yet, they have a soft spot for gardens. The traditional Bahraini architecture has been a typical incarnation of this keenness, as in courtyards, for it has been a definitive component of its housing scheme. Recently, this component; likewise; any façade greenery have vanished from the field. Therefore, recalling the greenery of building facades realize the User's appreciation that the Greenery upon the walls of the housing units is expected to meet unanimous agreement and gratitude by the Bahraini citizens. This would act as an alternative construction strategy to courtyards, by providing greenery on buildings' facades substituting gardens and social interactions (Henninger et al., 2015).

- Horticulture therapy interaction

Horticulture therapy affirms that greenery acquainted people are apt to master the stress management, controlling the panic attacks and blood pressure swings, thanks to their homing relaxing spaces (Shiah, 2011). The green view can be regarded as a natural driving force to:

(1) Encourage public participation in enhancing the urban quality of the participants' neighbourhood and getting over self-consciousness. Having such competitions is to be perfect for introducing the best performers to be awarded. This would probably help their self-esteem (Henninger et al., 2015).

(2) Having greenery upon building facades will motivate pedestrians. Also, it will encourage residents to beautify their sheltering urban environment, which is undoubtedly an indispensable social advantage of open spaces. It will impact positively in the social interaction thrives in communal areas; especially in pleasant environments. (Henninger et al., 2015).

- Aesthetic appeal

Visual quality by alluring treatment and decorative elements are substantial beatification factors for eye-catching green view buildings in a world stitched up with concrete and brick blocks. Another advantage that it makes up for the embarrassing mistakes in building with derogatory and inferior materials, letting them go unnoticed by increasing greenery in the targeted areas (urban-greening, 2017). Here, it will re-form the image of the city positivly, and decrease aesthetic pollution, which positively shows on social life.

7 PLANTS THAT ARE SUITABLE FOR DRY AND HOT CLIMATES

The researchers collected data by acting a survey, site studies in many nurseries in Bahrain, which was followed by comparative analysis for the types of the plants' species that could be used in the green wall in hot climate environment such as most areas of Bahrain. The significant plants' types are (Table 2):

(1) groundcovers, ferns, low shrubs, perennial

(2) flowers and edible plants

(3) pre-vegetated living walls offer an instant green wall for immediate impact.

8 TECHNICAL AND METHOD OF INSTALLATION:

There are several ways to install green walls, including:

(1) Using moulds: open tray plug (Figure 18) cohesive soil is used in the formwork with the seeds or small plants, and then they put on them the net that the young plants can pass through and at the same time prevent the soil from falling. Then it is hung on the wall through a wall-mounted structure, often made of steel, to withstand heavyweights. The irrigation process is done through water sprays or water channels (distillation).

Images	Name	Type Description
	Bahraini jasmine	outdoor plant (Climber) A plant that blooms in summer and spring. Its flower is white and smells strong and fragrant
	Allamanda	outdoor plant (Climber) Season: all seasons, it flowers are yellow, appearing in the summer. Use: for decoration. Very fast to grow
	Jacquemontia	outdoor plant (Climber) Season: all seasons, it flowers are purple, appearing in the winter. Use: for decoration.
	Silver queen	indoor plant Season: all seasons Use: for decoration.
	Money Plants (Epipremnum aureum)	indoor plant (Climber) Season: all seasons Use: for decoration.
	Dracaena	indoor plant Season: all seasons Use: for decoration

Table 3: Plants that are suitable for green walls in Bahrain

ISBN 978-3-9504173-8-8 (CD), 978-3-9504173-9-5 (print)
Editors: Manfred SCHRENK, Vasily V. POPOVICH, Peter ZEILE, Pietro ELISEI, Clemens BEYER, Judith RYSER, Christa REICHER, Canan ÇELIK

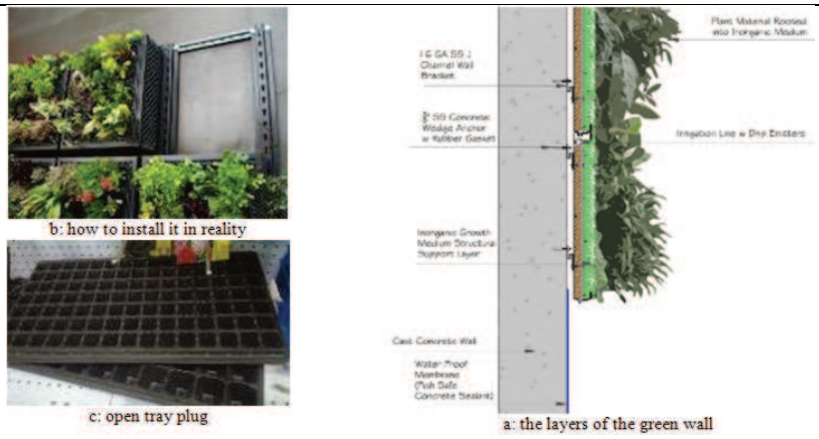


Fig. 13: Using molds open tray plug.

(2) Climbing plants: Climbing plants: They are placed or cultivated on the ground at the bottom of the wall, above the wall, or even in the middle of the wall, and then bamboo sticks or a grid structure of any materials are placed and installed on the wall, after that the plants grow on the net or sticks to be a green wall. Irrigation is usually done by spraying water. Applying this method is the easiest that it is the most common as well in Bahrain.(distillation).

Figure 14: Using climbing plants for green wall.

(3) Garden Spot: Pixel Garden is a unique system used in constructing vertical gardens, popularly known as Green Walls. Pixel Garden is setting new standards in buildings design, with the use of living flowers, which implement freshness, aroma and colours in its surroundings (figure 20). Each set consists of a box with two flower pots planted inside it. The system is designed in a way which enables the construction of a full flower wall with an innovative irrigation system.

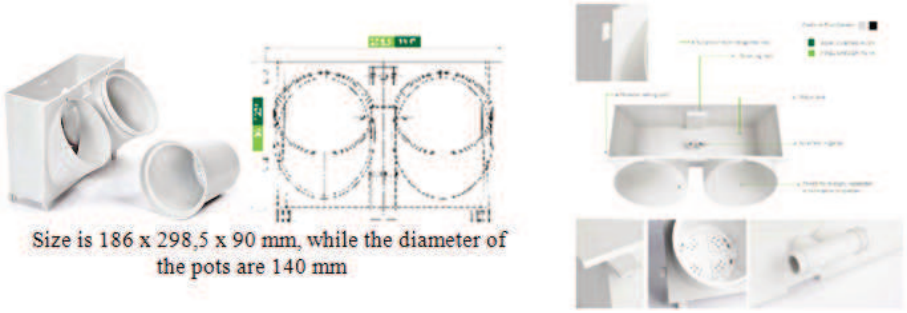


Figure 15: pots dimensions, which will produce the grids pattern of the facades

The Pixel Garden System offers enormous design possibilities and arrangements. Various colourful flowers in each pot can be used to create colourful pictures with diverse colour variations, blooming mosaics, floral inscriptions and sophisticated patterns with spectacular visual effects. The Pixel Garden's vertical gardens offer enormous possibilities of arrangement. Flowers in small pots, like pixels, create colourful pictures. The system is not only used as decorative nature. It has a multi-functional usagesuch as Traditional Vertical Gardens, Sound Barriers, Fences or hoardings and Partition Walls

9 FINDINGS AND CONCLUSION

After doing a market survey in Bahraini market, it was found that in general, the concept of dealing with greenery upon building walls is to use the lightweight system to make it possible and up to 25 m high, can be extremely dramatic visually, as well as softening what may be seen as hard surfaces. These green walls made of parts to enable the arrangement in attractive shape with a significant degree of self-efficiency. It allows a large number of plants species to grow on a vertical surface – allowing the designer to use it in artistic freedom in their work. Climbing plants have traditionally been seen as 'add-ons' to buildings. They are using living material, which could be installed, in different positions above the building facades. For the present case of the buildings in the old part of Manama, climbers can be used on freestanding structures such as giant 'pergolas' or poles. While discussing the panel typology of vertical green walls, there are major four types of boards, which are:

(1) Panel systems: Benefits of a panel system:

(2) Tray systems; Benefits of green wall tray systems:

(3) Freestanding systems; Benefits of a freestanding system: Moss walls

In conclusion, having Vertical Greenery upon buildings facades play as isolation envelop for buildings facades and will adjust CO2 emission rates, which by turn enhances air quality and comfort. No question, it will improve using lighting, controlling temperature, humidity and develop ventilation for the building (interior and exterior spaces), to reach out for the aspired comfort level. Undoubtedly, introducing Vertical Greenery upon buildings facades to counter the UHI impacts is one of the leading vital solutions, is a sustainable solution to improve the environment and minimize the actual risk of UHI. Therefore, applying this idea is a priority for the desiners in terms of achieving sustainable city because of the following points:

- Economic: It can optimize a natural cooling process, which functions by breaking the vertical flow, to cool the surrounding air as the vertical circulation slows down. Furthermore, It will reduce the consumption of energy in cooling, which will reduce the Co2 that is resulting from using the fusel fuel in running the energy plants. Moreover, it will have positive impacts on the national economy by using productive types of plants, as explained earlier, which will become economic resources for the Bahraini family. Moreover, it will integrate the community with farming using and benefiting from developing the idea by having "Vertical farms" as well.
- Environmental: In energy curtailment of the buildings, it has thermally beneficial for hot, humid countries, benefiting from adding the thermal and sound insulation techniques by modifying the thermo-conductivity. That will help Bahrain to be self-sustainable in terms of reducing the UHI phenomenon, reducing the energy consumption in cooling; as well as; producing local nutrition and air filtering. Moreover, it is possible to realize better urban spaces by reducing glare.
- Technically: From the construction point of view, the existing buildings in Manama are old enough to make the insulation of thermal insulation is difficult. Applying the vertical green is simpler to do thermal insulation upon buildings' structures. Moreover, installing the concept of "ECO" technology to Vertical Green facades is essential to deal with the buildings that are difficult to add thermal insulation.
- Social: It binds nature to its urban environment, to foster the social interaction, economic growth, educational status and environmental conditions. Moreover, vertical greens provide shading and protection to the surface of the building to absorb less heat, which influences positively for the social activities inside and outside buildings.

10 ACKNOWLEDGEMENT

To Prof. Dr. Agr. Kai Tobias, Department of Spatial Environmental Planning, Technische Universitat Germany. Also, appreciating to Architect Ahmed Salem for his help in doing site studies.

11 REFERENCES

Abdelsalam, A.E.-S.: The future of green-roofs in Egypt: The economical and environmental benefits when installing green-roof on a residential building in Cairo. MSc Thesis, Faculty of Engineering, Cairo University, Egypt. Retrieved on 29-4-2019 from: http://erepository.cu.edu.eg/index.php/cutheses/article/view/3337, 2012

ISBN 978-3-9504173-8-8 (CD), 978-3-9504173-9-5 (print)
Editors: Manfred SCHRENK, Vasily V. POPOVICH, Peter ZEILE, Pietro ELISEI, Clemens BEYER, Judith RYSER, Christa REICHER, Canan ÇELIK

Ansglobal. Bahrain. Retrieved from Ans Group Global: https://www.ansgroupglobal.com/locations/bahrain?gclid=Cj0KCQiA-8PjBRCWARIsADc18TI3MIpT2UjqVQt82qrsRCNpT4zcMOpIjWVclp6xeJ9TVQJxPxsm1MoaAosoEALw_wcB, 2019

Al Aali, M.: A house in Bahrain. MSc Thesis The Faculty of the Virginia Polytechnic Institute and State University in partial fulfillment of the requirements for the degree of Master of Architecture; Approved on 6 September 2006, Blacksburg, Virginia, p 1. Retrieved on 9-4-2019 from: http://hdl.handle.net/10919/35107, 2006

Al Hashimi, K. A.: A Bioclimatic Study on Housing Patterns in Bahrain. Arizona, 1996

Ambius: The ultimate guide to living green walls. Retrieved from Ambius: https://www.ambius.com/green-walls/ultimate-guide-to-living-green-walls/#what-are-living-green-walls, 2019

Al-Nuaimi, S. F. and Khamis, K. A.: Interior Finishing to Reduce Energy Consumption: Bahrain Experience. Proceedings of Gulf Engineering Forum, Muscat 2014. Retrieved on 25-6-2019 from: http://www.ose.org.om/gef/images/pdfs/Interior%20Finishing%20to%20Reduce%20Energy%20Consumption%20Bahrain%20Experience%20Dr%20Saad%20Al%20Nuaimi.pdf, 2014

Andromedadistrict: The benefits of living green walls. Retrieved on 22-5-2019 from: https://andromedadistrict.com/green-wall-benefits0, / 2007

Darwish, A.: Sustainable green smart buildings: Future energy survivor. ISESCO Journal of Science and Technology. 12(21): 35-42. Retrieved on 1804-2019 from: https://www.isesco.org.ma/ISESCO_Technology_Vision/NUM21/doc/5.pdf, 2016

Elghonaimy, I. and Elghonaimy, M. 2017. Landscape architecture significance in restoration historical areas, Case of old "Muharraq" city, Kingdom of Bahrain. Proceedings of the 2nd Silk Cities International Conference, Reconnect Population to Urban Heritage in the Middle East & Central Asia, 11-13 July 2017, University College, London, United Kingdom. Retreived on 13-6-2019 from: https://www.researchgate.net/publication/334374167_Landscape_Architecture_Significance_in_the_Restoration_of_Historical_Areas_Case_of_Old_Muharraq_Kingdom_of_Bahrain

Elghonaimy, I., Mohamed, W., M. H.: Urban Heat Island in Bahrain: Urban Perspective, Buildings journal. ISSN 2075-5309. 9(4): 96, 10, Published April 2019. Retrieved on 25-6-2019 from: https://www.researchgate.net/publication/332585362_Urban_Heat_Islands_in_Bahrain_An_Urban_Perspective , https://www.mdpi.com/2075-5309/9/4/96, 2019

Guzmán, J.M., Martine, G., McGranahan, G., Schensul, D. and Tacoli, C. (eds.): Population Dynamics and Climate Change. UNFPA (the United Nations Population Fund) and IIED (International Institute for Environment and Development). Retrieved on 5-5-2019 from: https://www.unfpa.org/sites/default/files/resource-pdf/pop_dynamics_climate_change_0.pdf, 2009

Henninger, S., Elmarsafawy, H. and Tobias, K: Bahrain regains greenery. Journal of Environmental Protection. 6(9): 929-934. Retrieved on 13-6-2019 from: DOI: 10.4236/jep.2015.69082, https://www.researchgate.net/publication/282464059_Bahrain_Regains_Greenery and https://file.scirp.org/Html/1-6702725_59305.htm, 2015

Indexmundi: Bahrain - CO2 emissions: CO2 emissions from gaseous fuel consumption (kt). Retrieved on 22-5-2019 from: https://www.indexmundi.com/facts/bahrain/Co2-emissions, 2018

Knoema: Bahrain - Agricultural land area. Retrieved on 23-5-2019 from: https://knoema.com/atlas/Bahrain/Agricultural-land-area, 2018b

Knoema: Bahrain - CO2 emissions from residential buildings and commercial and public services as a share of total fuel combustion. Retrieved on 23-5-2019 from: https://knoema.com/atlas/Bahrain/topics/Environment/Emissions/CO2-emissions-residential-buildings-percent, 2018c

Knoema: Bahrain - Urban population as a share of total population. Retrieved on 23-5-2019 from: https://knoema.com/atlas/Bahrain/Urban-population, 2018a.

Martin, T.: How urban planning can help us cope with climate change. Retrieved on 19-6-2019 from: https://www.archdaily.com/909476/how-urban-planning-can-help-us-cope-with-climate-change/?utm_source=Whatsapp&utm_medium=IM&utm_campaign=share-button, 2019

Nuruzzaman, M: Urban heat island: Causes, effects and mitigation measures - A review. International Journal of Environmental Monitoring and Analysis. 3(2): 67-73. doi: 10.11648/j.ijema.20150302.15. Retrieved on 13-6-2019 from: https://www.researchgate.net/publication/283507719_Urban_Heat_Island_Causes_Effects_and_Mitigation_Measures_-A_Review, 2015

Payne, D., Christner, M., Turner, Q. and Sapochetti, G: The cost of green roofs vs. conventional tar roofs. Retrieved on 25-5-2019 from: https://web.wpi.edu/Images/CMS/UGP/quantay-turney-2-poster_for_AFC.pptx.pdf, 2007

Unkown, : Planters, Why is vertical gardening important? Retrieved on 18-6-2019 from: https://www.planters.ae/blog/why-is-vertical-gardening-important, 2018

Shiah, K. and Kim, J.W.: An investigation into the application of vertical garden at the new SUB atrium. The University of British Columbia. Retrieved on 3-6-2019 from: https://open.library.ubc.ca/cIRcle/collections/undergraduateresearch/18861/items/1.0108430, 2011

Sobstyl, J.M., Emig, T., Abdolhosseini Qomi, M. J., Ulm, F.-J. and Pellenq, R. J.-M: role of city texture in urban heat islands at nighttime. Physical Review Letter. 120 (10): retrieved on 5-7-2019 from: https://journals.aps.org/prl/abstract/10.1103/PhysRevLett.120.108701, 2018

SOM Consultancy Project for Bahrain: Bahrain National Planning Development Strategy. retrieved on 3-7-2019 from: https://www.som.com/projects/bahrain_national_planning_development_strategy, 2007

Urban greening: Benefits of green walls. Retrieved on 22-6-2019 from: https://www.urbangreening.info/benefits-of-green-walls,2017

Wolfinbarger, S., Drake, J., Ashcroft, E. and Hughes, A.. Geospatial technologies and human rights project, 2014. Investigating land use and land cover change in Bahrain: 1987:2013. American Association for the Advancement of Science (AAAS). Washington DC. Retrieved on 2-6-2019 from: https://www.aaas.org/resources/investigating-land-use-and-land-cover-change-bahrain-1987-2013, 2014.