

Evaluation of perception with regards to green wall systems application in Nicosia, N. Cyprus



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ABSTRACT

Cities are exposed to rising temperatures due to the increased development of construction and the lack of green spaces etc. Materials such as concrete and asphalt absorb the heat and store it during the daytime, and then release at the night, leading to an increase in the temperature of the earth's atmosphere. This phenomenon is called an urban heat island (UHI). Therefore, the necessity of green architecture began to be well understood in the 21st century and new technologies began to be used in buildings such as "green walls". The existing application of green wall systems can maximize the building performance and can provide outdoor and indoor comfort and wellbeing with the help of functional, environmental, social and psychological benefits of plants. In addition to the lack of green areas, there is an increase in population in northern Nicosia and intense urbanization has been experienced recently. It can be argued that there is a need for the applications of green architecture and design such as green walls etc. So, a questionnaire was conducted in order to understand residents' suggestions about the possible implementation of green walls in the city. The data is assessed via the 'Statistical Package for the Social Sciences' (SPSS) program and the results displayed that participants are aware of the problems facing the city regarding human activities. In addition, they suggested that the system of green walls is an important solution to reduce air pollution, noise and temperature. They supported the application of green walls on the buildings in northern Nicosia. Thus, the application of green walls on buildings can be proposed to be a new strategy for making urban environments more sustainability-oriented in north Cyprus.

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1. Introduction

Nowadays cities have great challenges in managing and reducing human influences on the environment, where nearly half of the world's population lives in urban areas. The rapid rate of urbanization and the enormous increase of urban areas highly contribute to climatic differences between urban and rural areas. High temperatures in urban areas contribute significantly to global warming (Perini and Magliocco, 2012).

In other words, there is an ongoing rapid urbanization process worldwide (Vijayaraghavan, 2016). The vegetation areas are decreasing and built

environments are increasing. Because of this mass urbanization, several catastrophes such as global warming and climate change have emerged.

Urban heat island (UHI) is one of these threats that humanity has faced recently; it is the most documented phenomenon of climate change (Razzaghmanesh et al., 2016). As these catastrophes have been experienced, ecological planning and design have become a solution in each level of urban environments starting from the building level. Within this framework, issues like green roofs, green buildings and green spaces etc. have gained importance. Within the building level, topics such as living walls and green facades that can be defined as vertical greening have also been among current scientific methods as a solution (Santamouris, 2014).

Vertical greening also called a vertical garden, is covering vertical surfaces by vegetation. Living walls and green facades are among the main types of vertical greening. The vertical greening is convenient for urban environments because in the urban environment the vertical extent is numerous while

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the ground space is very limited. In other words, vertical greening is a significant example of merging nature and structures. Green envelopes can be a variety of plants which grown-up in growing medium on a small quantity of it in order to solve environmental problems in urban areas and today's ecological issues (Perini et al., 2011).

North Cyprus has faced rapid urbanization in the last twenty years. As a result, with the lack of green areas, buildings increased leading to the rise of construction materials such as concrete and asphalt in the city. This process is causing temperature rise in the atmosphere of the city, noise and dust in addition; it also decreases human wellbeing and quality of life. Therefore, it seems that, in order to solve problems in the city, sustainable urban planning solutions are crucial. As systems of green walls, a method of vertical greening, are among these sustainable urban planning and design solutions, this study aimed at measuring north Nicosia residents' suggestions about applying the green walls systems on the buildings.

Within this framework in this study, after a theoretical evaluation of the relevant literature review, the results of a user survey are analyzed and evaluated. The survey was conducted for measuring 'the perception about urban problems and the application of green walls' among citizens in north Nicosia. Lastly, a discussion is derived based on the related literature review and user survey results.

2. Literature review

2.1. Urban heat island

It is known that roads, pavements, concrete surfaces and walls all absorb sunlight during daytime and reflect heat as heatwaves at night (Atak et al., 2019). In cities, the temperatures of air, surface and soil are almost higher than in rural areas. This phenomenon is known as urban heat island.

Urban heat island refers to the relative warmth of air temperature near the ground and the urban heat island form of the atmosphere indicates the difference in temperature between urban and rural areas. Heat island can indicate the high temperature of the atmosphere with both forms of canopy layer heat island (CLHI) and boundary layer heat island (BLHI). It can indicate the relative warmth of urban surfaces with its surfaces heat island (SHI) form. Air temperatures are measured for CLHI and BLHI by direct thermometers, while SHI is measured using remote sensors installed on satellites or aircraft (Priyadarsini, 2012).

In the 19th century, the first influence of the urban heat island has appeared in London, resulting to become the most prominent during the low-winds and pure-weather at night. The problems of UHI are appearing in the summer more than the winter, as the evaluating of UHI returns to the periods that have arisen of high temperatures (Ashie, 2008).

Urban areas are associated with thermal islands, where islands affect the population negatively, as

high temperatures have a significant impact on human health. In addition, building materials such as concrete and asphalt are considered as a factor increasing the heating of the atmosphere, as well as the movement of population and transportation also has a role in raising the temperature of the atmosphere (Ichinose et al., 2008).

Heat island in its CLHI form density increases over time between sunset and dawn hours. The CLHI density is weak and negative to some extent during the day in some parts of the cities where heat is stored in building materials and the warming is delayed due to the shade which is formed from high buildings so the heat island, in this case, is a cool island. Solar radiation affects surface temperatures in the day so the urban surfaces are warm thus the SHI density is large and very positive in the day and night. And the BLHI density is much smaller than the density of CLHI and SHI and it is positive in the day and night generally (Roth et al., 1989).

To mitigate the rise of heat island, it is difficult to make major changes with regards to the urban surface engineering. Such as the spacing between buildings is practically impossible but there are other strategies like the use of a lightweight and light-colored materials on the facades of buildings and an increase of vegetation in the urban area via the application of greening techniques on the building's surfaces and the increase of green spaces. Hence the use of plants is a biological solution that contributes to limit urban heat where vegetation provides shade and helps cool air through evaporation (Rosenfeld et al., 1995).

For instance, monitoring the urban heat island in many areas of New York City, 2°C difference of temperatures have found between the most vegetated areas and the least vegetated areas, that was because of the man-made building materials that substitution of vegetation (Susca et al., 2011).

2.2. Green walls

The building envelope forms a fundamental thermal barrier between the exterior and interior of the building and contributes to the provision of the conditions necessary for thermal comfort within the building. Also, the building envelope has a role in reducing the use of energy needed to heat and cool a building. It is important to consider design elements for making a cooler building envelope so achieving less heat radiation into the surrounding environment in order to decrease the environmental impacts of the building and to reduce the urban heat island.

Green walls are a modern method of greening and can integrate living nature with urban environments. Green walls can be interior or exterior, free-standing or wall-attached. It has many benefits in addition to aesthetic benefit. Green walls have two systems as green facades and living walls (Pérez et al., 2011). The green wall systems and their sub-systems can be seen in Fig. 1. In green facades, the plants are rooted

in the ground and need a long time for covering the surface.

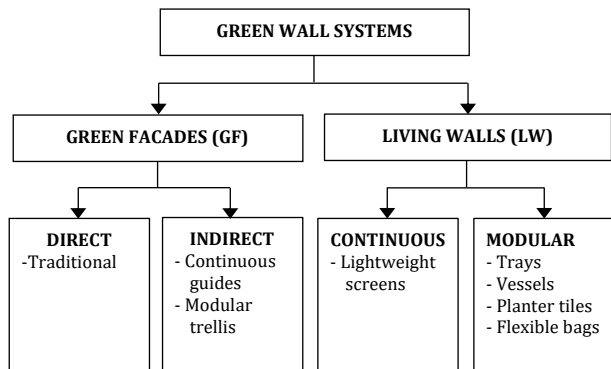


Fig. 1: The green wall systems classification (revised from Manso and Castro-Gomes, 2015)

The connotation of green walls refers to the greening systems of vertical surfaces (such as walls, facades, partition walls, blind walls, etc.) with plants, including the growing of plants on, up or within the wall of a building. The green walls can be divided into three main types according to the species of the plants, types of growing media and construction method. These three types are wall-climbing green walls, hanging-down green walls and module green walls (Sheweka and Magdy, 2011).

Furthermore, studies have proven that the greening of building envelope contributes to noise reduction. Where the study of the effects of green walls and green roofs at residential urban areas in the spread of traffic noise and the results showed that the green surfaces provide a high potential of calm. And that the green walls are more effective than the green roofs when applied to narrow city canyons. The integration between green roofs and green walls shows more interest (Renterghema et al., 2013).

2.2.1. Types of green wall systems

Green facades: The green facade system adopts two principles of plants, climbing plants that grow up on the vertical surfaces like traditional examples, and plants hanging along the wall which grow-down on the vertical surface as suspended at a certain height (Köhler, 2008).

Green facades can be categorized as direct or indirect. In the direct green facades, the plants are directly on the wall as in traditional green facades where plants are rooted directly in the ground. The direct type of green facades depends on climbing plants that grow along the wall while the indirect green facades include a supporting vegetation structure and the facades are double and form a space between the wall of the building and the vegetation, as in the new solutions of green facades (Perini and Rosasco, 2013).

Living walls system (LWS): Living walls system is a modern system of covering the facades of buildings. It allows quick coverage of large surfaces and supports the growth of plants consistently along

the vertical surface, which helps to integrate green walls that envelope the high buildings. Living walls can incorporate a variety of plants and can be applied to all types of buildings. According to the method of application of a living wall system, it can be classified as continuous or modular.

Continuous living wall systems depend on the application of lightweight and permeable screens in which plants are inserted individually. Continuous LWS is also called as vertical gardens (Ottelé et al., 2010). Modular living wall systems are elements either supported by a supplementary structure or constant directly on the vertical surfaces, these elements have a specific dimension. Elements of the living wall systems include development media that contribute to the growth of plants (Lu and Lin, 2015).

Living walls include the growth medium of plants in its structural system or on the surface and it contributes to rapid coverage of the surface. The green walls are characterized by many benefits including air purification and ambient temperature to reduction, in addition to the feature of decorating the urban environment built from concrete and bricks. Energy savings, biodiversity support, storm-water control, and noise attenuation can also be listed among these benefits (Azkorra et al., 2015). Studies have shown that nature positively affects the psychological state and reduces tension because our bodies are automatically affected by nature and this is called the concept of "Biophilia".

2.2.2. Vegetation and maintenance

There are many plant species that can be used to green the building. The most common are climbing plants, which are the cheap greening solution. It can be divided into two types, depending on the type of leaves; plants with evergreen leaves and deciduous plants. Evergreen plants maintain their leaves throughout the year. Deciduous plants lose their leaves during the fall, resulting in an optical change throughout the year (Adams, 2009).

Climbing plants can be self-supporting as they can bind themselves to the wall automatically (root climbers and adhesive-suckers), they may need a support structure such as a trellis to extend across the entire wall (twining vines, leaf-stem climbers, leaf climbers and scrambling plants). Climbing plants differ in their ability to extend in different distances depending on their species, some achieve an extension 5-6 m, others 10m and others achieve about 25m, and they take 3-5 years to fully cover the wall. The surface covering speed varies depending on temperature variations, climatic conditions, rainfall variation throughout the year, and leaf density (Perini and Magliocco, 2012).

For a greening system achieving the sustainability objectives, local plants adapted to climatic conditions should be selected and the vegetation with low irrigation needs. Modular living wall systems add feature to use succulent carpets instead of shrubs and perennials plants, where it is possible

to apply a range of plants that are lightweight, low maintenance, drought-tolerant and thus reduce the need for irrigation systems. Continuous and modular living wall systems are new concepts of the green wall that contribute to the integration of vegetables and aromatic herbs in the green façades are suitable solutions for cities with low agricultural land and this gives more functional possibilities for the greening system.

The plants are periodically exposed to pests and insects, maybe in outdoor vertical or horizontal gardens, therefore it is essential to protect the plants and surrounding environment from insects. In addition, regarding the green wall maintenance, it can be argued that the maintenance of a living wall should not be more demanding than the maintenance of any landscape planting. The living wall that is placed high on a building can be designed as a removable screen in order to reduce the use of lift equipment to maintain it. The early understanding of a living wall in the building design can greatly decrease maintenance costs. The maintenance regime should be established well-understood at the designation stage in order to improve the survival of the wall.

The maintenance of green walls involves a range of processes including routine and special ones: These processes are, vegetation growth monitoring; irrigation equipment checks; in-service control of materials and components; the number of pruning planned per year. While special maintenance is included with anti-parasitic treatments, material and components repair and replacement and irrigation system repairs (Giordano et al., 2017).

2.3. Applications of green wall systems in different climates

Climate is the most influential factor in the study of green walls. In the hotter and drier climate, the effects of the green coverage on the urban temperature are more significant. The green surfaces can be effective in the humid climates for urban temperature reduction, especially when both walls and roofs are green. The greening of surfaces contributes to absorbing more solar radiation and leads to a higher reduction of temperature. So, the hotter and drier the climate, the higher is the efficiency of the green wall as well as temperature reduction. This degree of temperature reduction can result in a significant annual saving. The LWS creates more stable relative humidity in the air layer near the wall surface without increasing the relative humidity of indoor air (Zarandi and Pourmousa, 2018).

The huge influence of weather conditions must be considered for the potential of vertical greening systems with regards to saving energy in buildings. In addition, the effect of climate on the thermal performance of the building, the effect of weather on the plants' growth and on their physiological responses must also be determined. Thus the thermal behavior of vertical greenery systems will also depend on weather conditions which consequently will affect the results. According to many types of research, the Köppen Climate Classification System can be suggested to be used for the appropriate consideration of the climate for the vertical green systems (Pérez et al., 2014). The Köppen Climate Classification System, period (1980-2016) is displayed in Fig. 2.

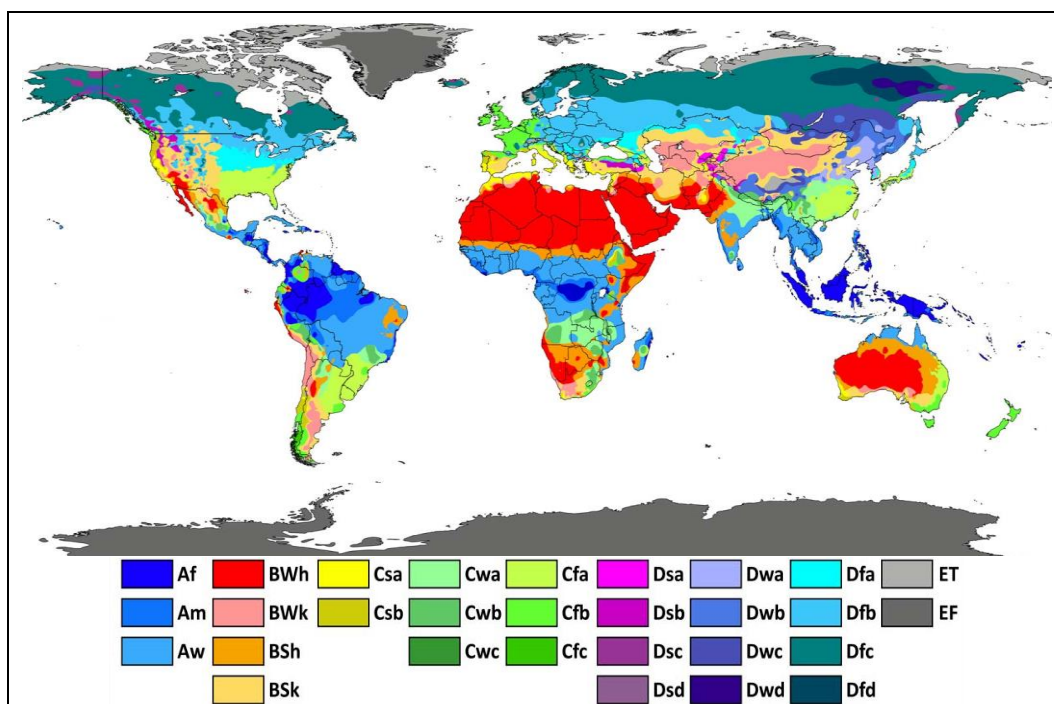



Fig. 2: The Köppen Climate Classification (Beck et al., 2018)

Table 1: Application of green wall systems on the council house 2 of Melbourne

	<ul style="list-style-type: none"> • 90 molded plastic black containerized planters are formation the facade. • The planters installed on small balconies on the north facade of the building. • Each planter is 0.3m * 0.97m at the surface, 0.89m in depth, volume 260 L. • 1m in width (150mm aperture size), steel cable x-tend mesh trellis was used behind the planters and above them, forming a vertical screen on the building.
<p>Climate region Green wall system</p>	<p>Temperate subtropical oceanic, with mild winters and pleasantly warm summers. Modular living wall system.</p>
<p>Vegetation</p>	<p>164 plants from five taxa were used: Clematis aristata, Kennedia Nigerians, Pandorea pandora and Trachelospermum jasminoides are among these taxa. Due to death or poor cover values, approximately 61% of plants were classified as 'failed'. Pest infestation and stress symptoms were particularly widespread in surviving Kennedia spp. of the five plants used in the project, only Pandorea pandora had low rates of failure (6.2%).</p>
<p>Irrigation system</p>	<p>The lower levels and eastern sides of the building were locations for the greatest rates of failure across all species Controlled by a foot valve connected to the water supply, a sub-irrigation system encompassing as small cistern at the base (10 cm depth).</p>

Application of green wall systems in three different climate regions are given in three examples as below.


Example 1: CouncilHouse 2 is the municipal offices of the City of Melbourne opened in October 2006. It was the first six-star rated green building in Australia. The building has nine stores and supports a semi-extensive green roof and green wall (Rayner et al., 2010). Table 1 shows the application of green wall systems on the council house 2 of Melbourne.

Example 2: The National Institute of Social Insurance (Istituto Nazionale di Previdenza Sociale) is located in Genoa's Sestri Ponente district in the

north of Genoa, Italy (Magliocco and Perini, 2015). Table 2 shows the application of green wall systems on the building of the national institute of social insurance in Genoa, Italy.

Example 3: The Paul-Lincke-Ufer research project was the first urban research project in Berlin. It began in 1984 as the restoration of a 100-year-old apartment building. Parthenocissus tricuspidata (Boston ivy) and other climbers were planted in vegetation pots on the facades and on the garden level (Köhler, 2008). Table 3 shows the application of green wall systems on an apartment building in Berlin, Germany.

Table 2: Application of green wall systems on the building of the national institute of social insurance in Genoa, Italy

	<ul style="list-style-type: none"> • The green facade was installed in October and November 2014 on the south wall of the building. • Building structure: concrete pillars and beams. • The facade is insecure about solar radiation several hours per day in summer and 1-2 hours per day during winter.
<p>Climate region Green wall system</p>	<p>The Mediterranean, with mild, rainy winter and hot, sunny summer. Living wall system.</p>
<p>Vegetation</p>	<p>A mat planted with different plant species (shrubs, climbing plants, evergreens) is used for the living wall system. An aggregate mix is used in the mat and the mat is composed of special geotextile as two layers.</p>
<p>Irrigation system</p>	<p>A drip line in each module is used for the irrigation system and the system is designed primarily to use recycled condensate water from a network of air conditioning units.</p>

3. Materials and methods


3.1. The research context

Cyprus is the third largest island in the Mediterranean with two mountain ranges: The Troodos Mountains and the Kyrenia Range. Its location plays an important role in shaping its 10,000-year history. It is also one of the most important tourist destinations in Europe. It has more than 300 days of sunshine throughout the year. Cyprus as a country has an ancient historical charm

with many ancient monuments and historical rural and urban sites.

The island has been under the control of many empires and kingdoms for many years due to its geographical location. Civilizations such as Romans, Venetians, Lusignans, Ottomans were once ruled the island. In the 1930s, the history of modern architecture began in Cyprus, where ideas were presented by European architects who came to Cyprus to present modern architectural ideas.

Table 3: Application of green wall systems on an apartment building in Berlin, Germany

	<ul style="list-style-type: none"> • Paul-Lincke-Ufer. • The restoration of a 100-years-old apartment building. • Parthenocissus tricuspidata (Boston ivy) covered the facades for nearly 10 years. • Over a 10 years period, the ground-based climber species had reached the gutter at the edge of the roofs, during the survey study.
Climate region	Cold winters, with average temperatures around freezing (0°C or 32°F), and moderately warm summers, with daytime temperatures hovering around 24 °C (75 °F), moderately continental.
Green wall system	Green façade.
Vegetation	Hanging planter boxes and Boston ivy was planted to bring the most possible vegetation into the small inner courtyard.

Nicosia is the capital of the island and it is located at the intersection of the main road network connecting Famagusta, Kyrenia, and Güzelyurt. The city of Nicosia is the only divided capital in the world (Bolkner et al., 2019). Such that it is divided into two, as north and south Nicosia. North Cyprus has five main provinces as Nicosia, Famagusta, Kyrenia, Güzelyurt and Iskele. North Nicosia is the capital city of North Cyprus. According to 2011 Census north Nicosia de-jure population is 94,824 (49,838 males, 44,986 female) (Fig. 3).

3.2. The sample

Gender: 48.0% of the 125 participants were female and 52.0% were male (Fig. 4).

- Age: 52.0% of the questionnaire participants had an age of 18-25 years, 35.2% were between 26-40 years old, 9.6% were between 41-55 years old, 2.4% were between 56-65 years old and 0.8% were between 66-75 years old. Fig. 5 shows Participants’ responses about “Age” (%).



Fig. 3: Map of Cyprus and North Nicosia

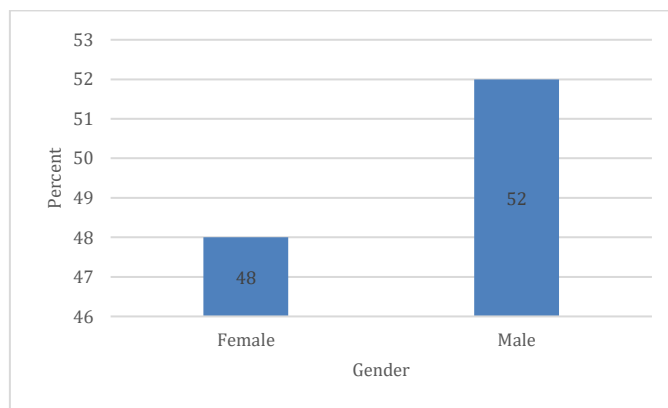


Fig. 4: Participants’ responses about “Gender” (%)

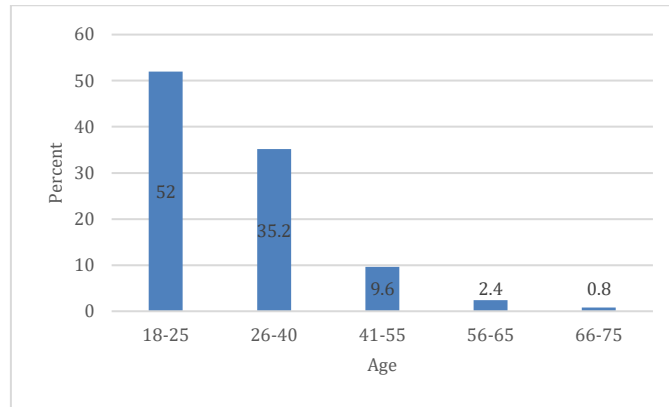


Fig. 5: Participants’ responses about “Age” (%)

- Education: 1.6% of the questionnaire participants had a secondary school degree, 16.0% had a high school degree, 64.8% had a university degree and 17.6% had a master or Ph.D. degree. Fig. 6 shows the Participants’ responses about “Education” (%).
- Nationality: 53.6% of the 125 participants were Cypriot, 32.6% were Turkish and 13.6% were from other nationalities.

Fig. 7 shows the Participants’ responses to “Nationality” (%).

Duration in Nicosia: 40.8% of the participants have been living in Nicosia for 1-5 years, 12.0% have been living in Nicosia for 6-10 years, 12.0% have been living in Nicosia for 11-20 years and 35.2% have been living in Nicosia for 20 years or more. Fig. 8 shows the Participants’ responses about “How long have you been living in Nicosia?” (%).

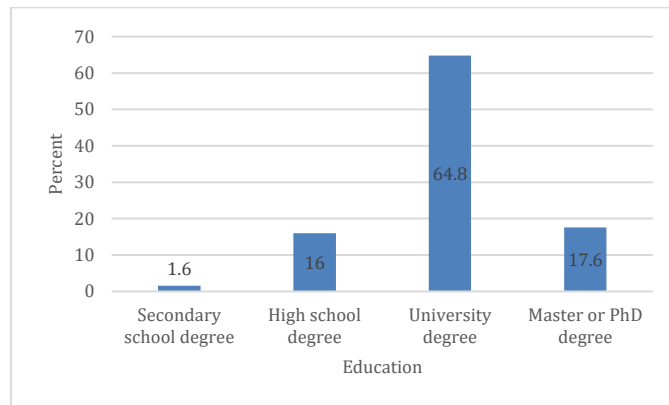


Fig. 6: Participants’ responses about “Education” (%)

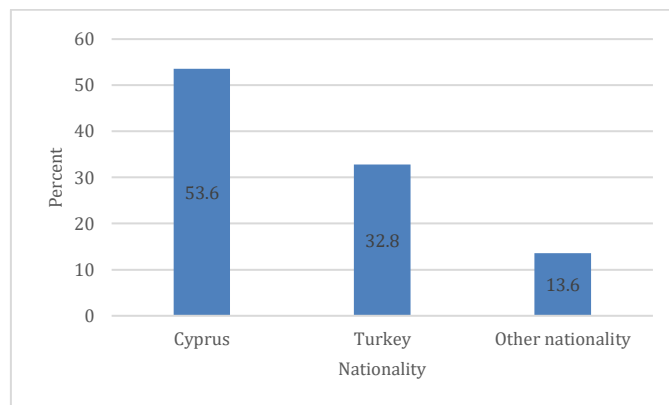


Fig. 7: Participants’ responses to “Nationality” (%)

3.3. Measures

The study involved a questionnaire having three sections. In the first section, the respondent's suggestions about urban problems of Nicosia generated because of human activities were investigated. In the second section, suggestions about applying green walls were examined and in the last section items about the participants’

demographic data were involved respectively. The questionnaire was randomly conducted in different locations of the city for the individuals living in Nicosia and participants interviewed face-to-face. It took three weeks in February 2019 to complete the field study of the survey. 125 individuals were selected randomly in total as respondents.

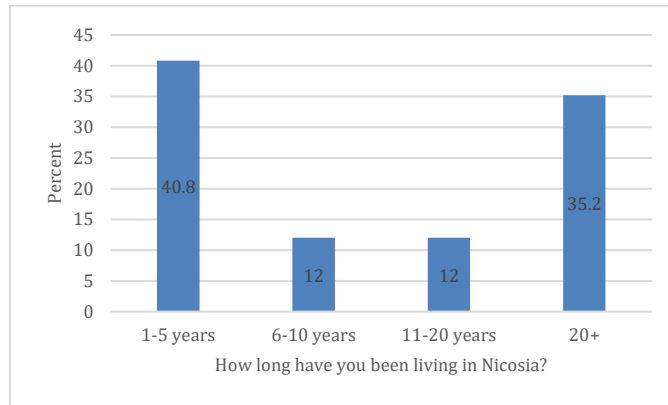


Fig. 8: Participants’ responses about “How long have you been living in Nicosia?” (%)

4. Results

4.1. The findings of the first section

In the first part of the questionnaire, three items were used. The results are evaluated and displayed below. 58.4% of the 125 participants strongly agreed, 28.8% agreed, 5.6% were unsure, 4.0% disagreed and 3.2% strongly disagreed with the item ‘The traffic and human activities are increasing and causing air pollution in the city of Nicosia’. Fig. 9 shows the Participant’s responses about “The traffic

and human activities are increasing and causing air pollution in the city of Nicosia” (%).

53.6% of the 125 participants strongly agreed, 32.0% agreed, 8.8% were unsure, 1.6% disagreed and 4.0% strongly disagreed with the item ‘The lack of green space and the increase of built-up areas in some cities of Cyprus such as Nicosia is one of the causes of air pollution and rising temperature’. Fig. 10 shows the Participants’ responses about “The lack of green space and the increase of built-up areas in some cities of Cyprus such as Nicosia is one of the causes of air pollution and rising temperature” (%).

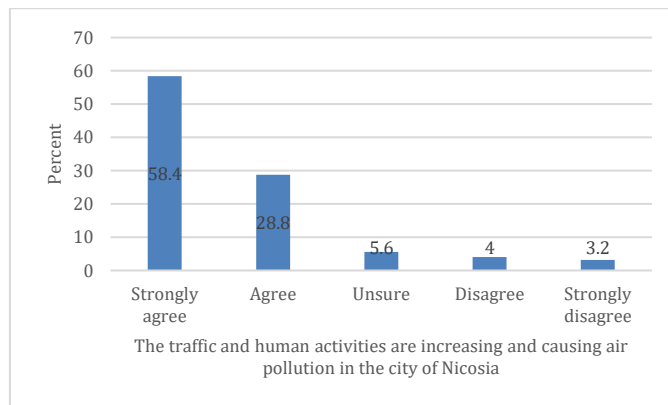


Fig. 9: Participant’s responses about “The traffic and human activities are increasing and causing air pollution in the city of Nicosia” (%)

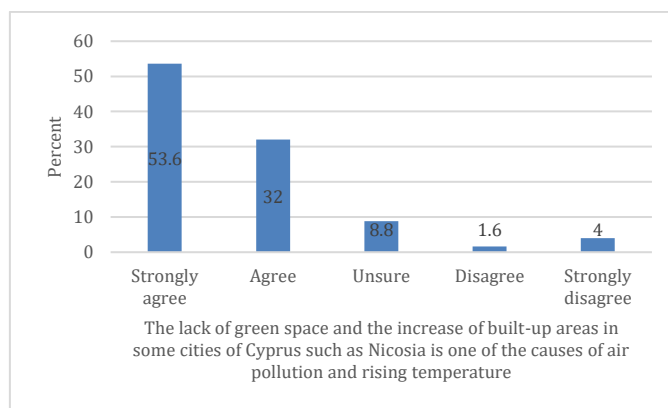


Fig. 10: Participants’ responses about “The lack of green space and the increase of built-up areas in some cities of Cyprus such as Nicosia is one of the causes of air pollution and rising temperature” (%)

43.2% of the participants strongly agreed, 30.4% agreed, 22.4% were unsure, 1.6% disagreed and 2.4% strongly disagreed with the item ‘The

vegetation in urban environments contributes to the rainwater absorption and purification before entering the drainage’. Fig. 11 shows the

Participants' responses about "The vegetation in urban environments contributes to the rainwater

absorption and purification before entering the drainage" (%).

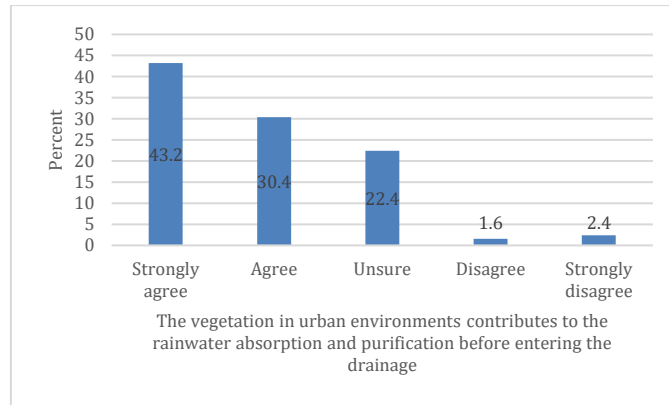


Fig. 11: Participants' responses about "The vegetation in urban environments contribute to the rainwater absorption and purification before entering the drainage" (%)

4.2. The findings of the second section

46.4% of the 125 participants strongly agreed, 37.6% agreed, 11.2% were unsure, 3.2% disagreed and 1.6% strongly disagreed with the item "The green walls contribute significantly to reducing the temperature of the atmosphere and thus the phenomenon of global warming". Fig. 12 shows the Participants' responses about "The green walls contribute significantly to reducing the temperature of the atmosphere and thus the phenomenon of global warming" (%).

32.0% of the respondents strongly agreed, 28.0% were agreed, 31.2% were unsure, 5.6% disagreed and 3.2% strongly disagreed with the item 'Plants in green walls absorb sound where they work as a sound barrier and reduce noise, thus reducing the noise pollution in the urban areas'. Fig. 13 shows the Participants' responses about "Plants in green walls absorb sound where they work as a sound barrier and reduce noise thus reducing the noise pollution in the urban areas" (%).

64.0% of the respondents replied strongly agree, 24.0% replied agree, 5.6% were unsure, 3.2% disagreed and 3.2% strongly disagreed with the item 'Green walls give an aesthetic advantage to the city'. Fig. 14 shows the Participants' responses about

"Green walls give an aesthetic advantage to the city" (%).

30.4% of the participants suggested strongly agree, 35.2% agree, 28.0% were unsure, 2.4% disagree and 4.0% replied strongly disagree for the item "The application of green walls on buildings contributes to thermal insulation thus saving energy costs for the building owner". Fig. 15 shows the Participants' responses about "The application of green walls on buildings contributes to thermal insulation thus saving energy costs for the building owner" (%).

49.6% of the respondents replied strongly agree, 40.0% agreed, 8.8% were unsure, 0.8% disagreed and 0.8% strongly disagreed with the item 'Plants induce psychological wellbeing thus the green wall systems have a therapeutic effect'. Fig. 16 shows the Participants' responses about "Plants induce psychological wellbeing thus the green wall systems have a therapeutic effect" (%).

50.4% of the participants suggested strongly agree, 35.2% agree, 9.6% were unsure and 4.8% suggested strongly disagree for the item 'I encourage the adoption of a green walls strategy in the buildings in Nicosia'. Fig. 17 shows the Participants' responses about "I encourage the adoption of a green walls strategy in the buildings in Nicosia" (%).

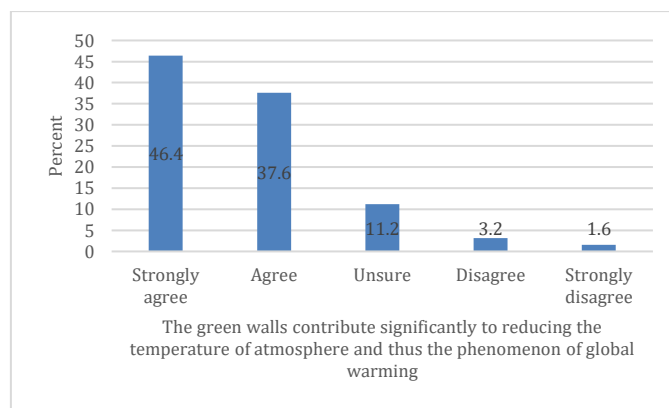


Fig. 12: Participants' responses about "The green walls contribute significantly to reducing the temperature of the atmosphere and thus the phenomenon of global warming" (%)

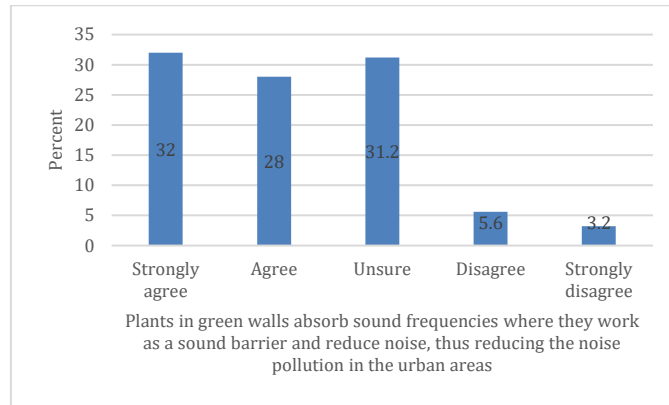


Fig. 13: Participants' responses about "Plants in green walls absorb sound where they work as a sound barrier and reduce noise thus reducing the noise pollution in the urban areas" (%)

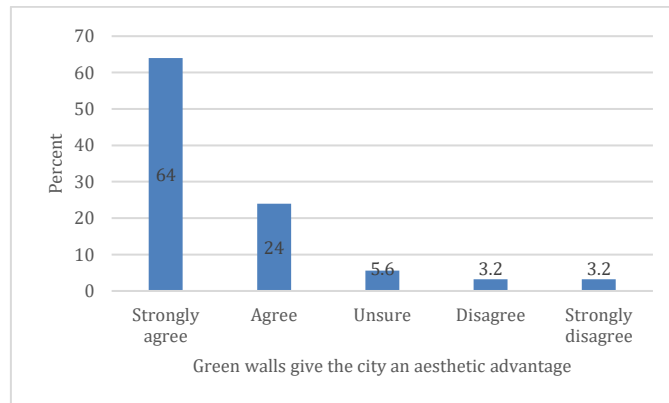


Fig. 14: Participants' responses about "Green walls give an aesthetic advantage to the city" (%)

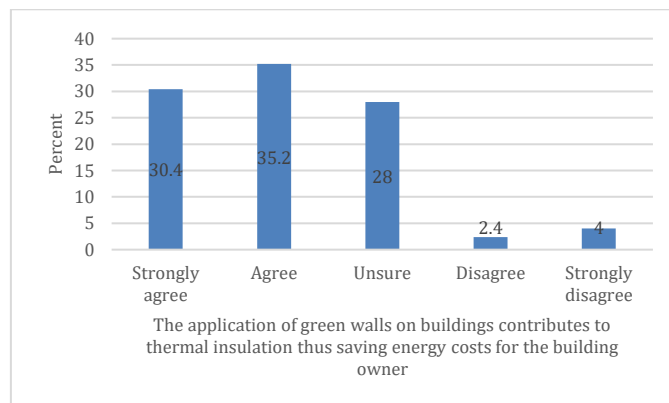


Fig. 15: Participants' responses about "The application of green walls on buildings contributes to thermal insulation thus saving energy costs for the building owner" (%)

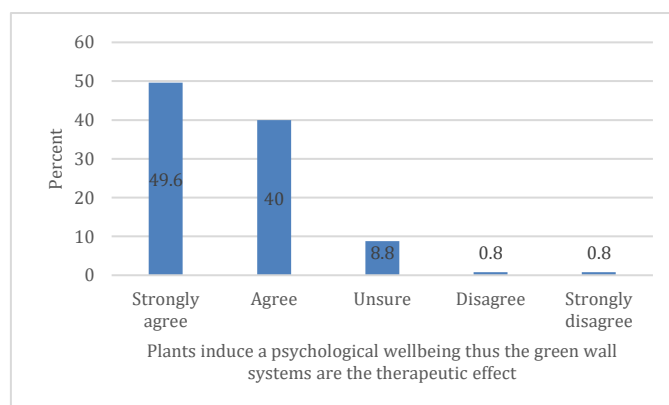


Fig. 16: Participants' responses about "Plants induce psychological wellbeing thus the green wall systems have a therapeutic effect" (%)

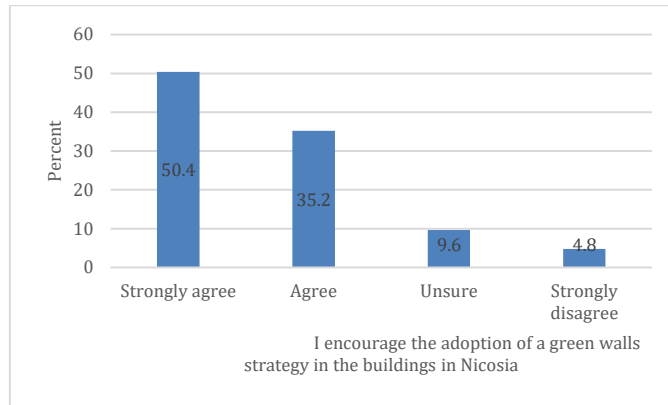


Fig. 17: Participants’ responses about “I encourage the adoption of a green walls strategy in the buildings in Nicosia” (%)

24.0% of the participants replied ‘yes’ and 76.0% replied ‘no’ about the item ‘Have you ever used a living wall or green facades in your living

environment?’. **Fig. 18** shows the Participants’ responses about “Have you ever used a living wall or green facades in your living environment?” (%).

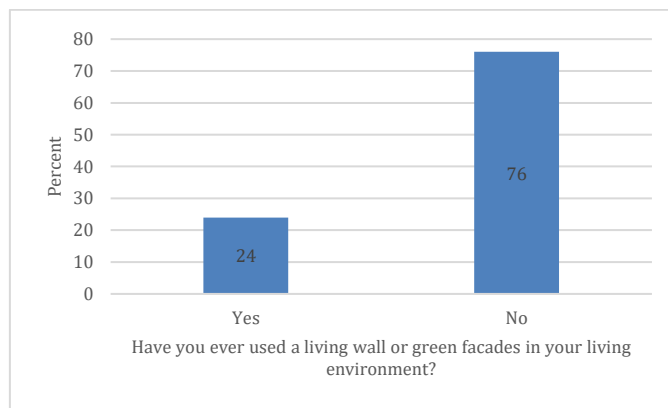


Fig. 18: Participants’ responses about “Have you ever used a living wall or green facades in your living environment?” (%)

37.6% of the 125 participants suggested ‘yes’ and 62.4% suggested ‘no’ about the item Have you ever used living plants for making shady environments such as car parking, semi-open/semi-closed spaces?

Fig. 19 shows the Participants’ responses about “Have you ever used living plants for making shady environments such as car parking, semi-open/semi-closed spaces?” (%).

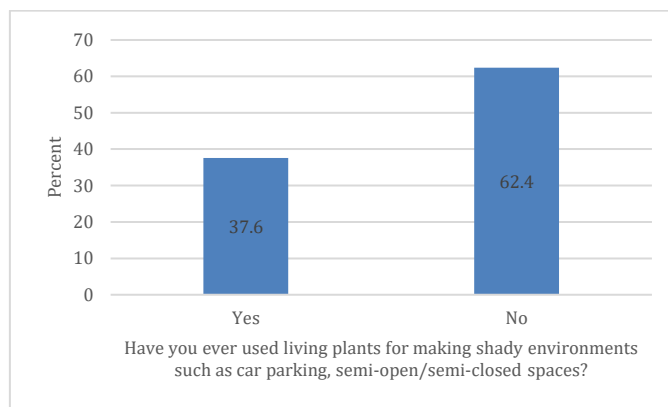


Fig. 19: Participants’ responses about “Have you ever used living plants for making shady environments such as car parking, semi-open/semi-closed spaces?” (%)

5. Conclusion

Buildings consume a lot of natural resources and this makes them cause many environmental problems. Buildings consume around one-third of global energy and generate about the same proportion of black carbon emissions (Murtagh et al., 2016). The increasing number of buildings and the development of urban environments lead to the

increase of solid building materials such as concrete that can absorb the heat of the sun during the day and release it at night, increasing the temperature of the surrounding atmosphere.

The urban heat island phenomenon refers to high temperatures in cities. Daily mean UHI typically ranges between 2 and 5°C, while UHI intensities (defined as the maximum difference between urban and background rural temperatures) up to 12°C

were registered under particular conditions. This UHI phenomenon has a considerable effect on important issues such as the quality of life, public health and environmental hazards, especially for the most vulnerable population (Zinzi and Agnoli, 2012).

According to the related research and studies in recent years, greening of buildings are among the most important solutions that can be applied in cities to solve environmental problems and mitigate the negative impact of buildings on urban environments; where urban residents need clean air, clean water, reduced pollution, improved environmental conditions, and green spaces.

The greening of buildings can be either horizontal greening such as green roofs or vertical greening, which is also called green walls. In recent years' green walls have become more widespread and numerous studies and research have been done about their benefits and application systems in different climates, where the climate is the most influential factor in the study of green walls.

Green walls in north Nicosia can be one of the tools for solving the urban problems of the city as there are an increasing population and construction facility in recent years. However, for the encouragement of such environmentally based applications that all have a direct or indirect positive effect on combatting ecological problems, public awareness and commitment seem to be a significant issue.

Thus the aim of this study was to investigate suggestions of Nicosia residents about green walls via a questionnaire. According to the results of the questionnaire, the participants achieve positive suggestions with regard to the issues related to the possible application of green wall systems.

However, the findings are controversial. Such that they suggested a remarkable positive perception towards any possible application of green wall systems; 46.4% of the 125 participants strongly agreed and 37.6% agreed with the item 'The green walls contribute significantly to reducing the temperature of the atmosphere and thus the phenomenon of global warming'. In addition, 50.4% of them suggested 'strongly agree' and 35.2% 'agree' for the item 'I encourage the adaption of a green walls strategy in the buildings in Nicosia'. But 62.4% of the participants suggested 'no' about the item 'Have you ever used living plants for making shady environments such as car parking, semi-open/semi-closed spaces.

Therefore, according to the results, it can be argued that a higher environmental commitment seems to be urgently needed to be adapted by the residents of the city. Hence the findings point out an action gap regarding the related ecologically-based greening applications. Besides the governmental and local initiatives and efforts supporting such ecologically-based applications including green wall systems, environmental awareness and concern of the urban residents leading to ecologically-based preferences as a lifestyle can be an influential tool for combatting global warming and climate change,

urban heat island etc., (Asilsoy, 2012; Asilsoy and Oktay, 2018).

Compliance with ethical standards

Conflict of interest

The authors declare that they have no conflict of interest.

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