ICONARP
International Journal of Architecture and Planning
Received: 21.05.2019 Accepted: 06.01.2020
Volume 8, Issue 1, pp:112-133/ Published: 25.06.2020
DOI: 10.15320/ICONARP.2020.107- E- ISSN:2147-9380
Research Article
ICONARP

Critical Aspects, Motivators and Barriers of Building-Integrated Vegetation

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Abstract

Purpose
Green buildings which provide improved user health conditions and environmentally responsible applications have gained significant attention, due to the increasing environmental problems, particularly caused by the construction industry at the global scale. However, vegetation is still not sufficiently integrated into buildings, even though numerous benefits of plants have been proven by many studies in literature.
This research aims to find out the opinions of professionals and academicians in architecture-related fields regarding the critical aspects, as well as the motivators and barriers faced in BIV applications, namely; green roofs, green walls and interior gardens. Hence, it strives to help increase their application rates by underlining the significant issues to be considered.

Keywords: *Building-integrated vegetation, green roofs, green walls, interior gardens*

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Design/methodology/approach
As to fulfilling these objectives, a questionnaire survey was conducted on 120 participants with varying professions including architects, landscape designers and civil engineers, from four countries.
Findings
The results of this study pointed out that, healthcare buildings were given the first priority among the building types for applying BIV. Moreover, among the motivator factors, receiving a certificate was found as an important incentive, besides the environmental, social and economic benefits of BIV. Furthermore, although the highly rated barriers were found as 'the lack of proper regulations' and 'lack of demand by the user/client', the findings showed that the highest responsibility for the implementation of these applications was placed on the architect.
Research Limitations/Implications
Based on the five major groups of Köppen climate classification system, the case countries were selected as one from each of the four main types, and by neglecting only Polar, as it lacks settlements. By considering diverse levels of development and economic welfare, countries were selected as; Canada (Snow: Humid-Subarctic), Libya (Dry: Desert-arid), Malaysia (Tropical: Tropical-Rain forest) and Turkey (Mild temperate: Mediterranean).
Since the study covered four different countries, the survey was conducted by the use of Google Forms software program. This tool enabled the production and distribution of questionnaires, as well as the collection of data based on the responses of the participants. Furthermore, in order to provide consistency among the questionnaires applied in different countries, the survey was conducted in English language, although it was not the native language for a majority of the participants.
Moreover, based on studies claiming that participants are more inclined to select the option with the mid-value in a Likert scale, which implies a *neutral* position, in the questionnaire, these types of questions were constructed with the *forced choice method*, by keeping the scales with even number of options.
Practical Implications
It is expected that the results of this study would be beneficial to both the academicians and professionals involved in the green building industry, as well as to the governmental and/or green building authorities. It is expected that this study will help serve as a guide for the stakeholders to increase the application rates of BIV in the construction industry.
Social Implications
The results of this study were also evaluated based on the findings of four case countries and certain conclusions were derived as to their underlying socio-economic and geographical reasons.
Originality/value - Although studies on similar subjects have appeared in the literature, there are none which solely focuses on BIV applications by conducting a survey on the mentioned four case countries and compares its findings with the literature and presents an in-depth analysis on the issue.

DOI: 10.15320/ICONARP.2020.107 E-ISSN: 2147-9380

INTRODUCTION

Humankind has been fulfilling his many crucial needs from nature since his first emergence on earth. Plants are highly important as they eliminate carbon dioxide (CO_2), carbon monoxide (CO), and some other toxic gases in the atmosphere via photosynthesis processes, which also help minimize negative effects on global warming and climate change. Recently, production and consumption of materials have dramatically increased due to the rise in urbanization rates, excessive use of energy, technological advancements, as well as industrial and economic developments. As a result, emissions of harmful gases have also increased, which has led to catastrophic consequences on the environment, and quality of life has deteriorated in urban areas because of the severely high levels of air pollution. Therefore, today, sustainable design of buildings, particularly in urban areas has become a fundamental issue to be considered. Building-integrated vegetation (BIV), which requires a multi-disciplinary and collaborative work of many professionals such as; architects, interior designers, landscape designers and engineers, offers a solution for lessening these environmental and social problems. In other words, application of green roofs, green walls and interior gardens, would help reduce air pollution and high temperatures, mitigate urban heat island effect and lead to energy savings in buildings and in urban areas.

By merging the living systems with the structural elements that currently dominate buildings, a fructuous type of architecture is created, which positively affects the quality of the exterior shell and the interior of the building, as well as its surrounding environment. The use of natural ventilation is undoubtedly one of the sound principles of sustainable building design. However, it should also be noted that using natural ventilation may cause outside air pollutants to enter buildings. As a consequence, exterior air pollution directly affects the indoor air quality of buildings. Moreover, when not properly maintained, mechanical ventilation systems can cause the spreading of air pollutants among the interior spaces of the buildings. Therefore, using BIV, namely applying green walls and gardens at interiors, offers a practical solution to improve indoor air quality as vegetation help filter the pollutants in air.

On the other hand, high exterior temperatures affect the indoor temperatures and increase the cooling loads of buildings, which result in higher energy consumptions. However, since green roofs and green walls act as extra layers of insulation, they help reduce the energy consumption in buildings. Moreover, green roof applications help reduce the heat island effect in urban areas (Dwivedi and Mohan, 2018), as Environmental Protecting Agency (EPA) stated that they "…provide shade and remove heat from the air through evapotranspiration, reducing temperatures of the roof surface and the surrounding air" (EPA, 2016) (p.1).

METHODOLOGY

Green buildings which provide improved user health conditions and environmentally responsible applications have gained significant attention, due to the increasing environmental problems, particularly caused by the construction industry at a global scale. However, vegetation is still not sufficiently integrated into buildings, even though numerous benefits of plants have been proven by many studies in literature. To be able to provide sustainable buildings which have lower energy consumptions than traditional buildings and help reduce the air pollution, BIV needs to be strongly promoted.

This research aims to find out the opinions of professionals, who are the decision makers in the construction industry, as well as academicians in the related field, regarding the critical issues, motivators and barriers of the mentioned green applications. By pointing out these aspects, their application frequencies are expected to be increased, and thus the environmental impacts of buildings on their surroundings and their users would be reduced in future developments.

As to the methodology of the study, a questionnaire survey was addressed to academicians and practitioners working in architecture-related fields with the aim of analyzing the critical issues, the opportunities and challenges of applying green roofs, green walls and interior gardens. The study was conducted on participants with diverse groups of professions including; Architects, Civil Engineers, Landscape Designers, Urban Designers, Planning Engineers, Agronomists and Investors. The participants represent different views from institutions related to the field of architecture from public and private sectors, which could affect the environmental, social and economic future construction developments in various locations.

This study comprises various countries with diverse geographical, climatic and regulatory conditions. According to the Köppen climate classification system, there are five major climate groups, which are; Tropical, Dry, Mild temperate, Snow and Polar (Chen and Chen, 2013). Based on these groups, the case countries were selected from four major climate types, by neglecting only Polar, as it lacks settlements. By considering diverse levels of development and economic welfare, one country from each major climate group was selected. These are; Canada (Snow: Humid-Subarctic), Libya (Dry: Desert-arid), Malaysia (Tropical: Tropical-Rain forest) and Turkey (Mild temperate: Mediterranean) (Chen and Chen, 2013). A total of 120 participants, with weightings of 60% practitioners and 40%

DOI: 10.15320/ICONARP.2020.107 E-ISSN: 2147-9380

academicians from institutions which are related to the construction industry and the field of architecture were included in this study. Leading companies and universities from the mentioned countries were selected to conduct the study, some of which are; Vitaroofs International Inc. (Canada), BH-Architects Office (Canada), Tatweer Research Company (Libya), Alemara Inc. (Libya), Teknologi MARA University (Malaysia), Lush Eco Sdn. Bhd. Company (Malaysia), Çankaya University (Turkey), Zorlu Holding (Turkey).

The questions in the questionnaire were grouped in four sections as to their types and contexts. These are; i.) Personal information of participants, ii.) Critical aspects of BIV, iii.) Motivators and barriers of BIV, and iv.) Future possibilities of BIV. The questions were constructed as clear multiple choice and ranking questions to determine the preference of participants related to the addressed issues, by avoiding any possible hesitations while answering.

On the other hand, in various studies in literature, it was found that participants are more inclined to select the option with the mid-value in a Likert scale, which implies a *neutral* position, or having *no opinion* (Lavrakas, 2008). Therefore, the questions with a Likert scale were constructed with the *forced choice method*, which is based on keeping the scales with even number of options that forces the participant to *actually* make a choice.

The survey was conducted in English language by the use of Google Forms software program. This tool enabled the production and distribution of questionnaires, as well as the collection of data based on the responses of the participants. As to analysing gathered data and extracting results by statistical reports, MS Office Excel and Statistical Package for the Social Sciences (SPSS) software programs were used. After that, a literature review on similar research topics was done for clarifying the obtained results and providing supporting findings for the study.

FINDINGS

Personal Information of Participants

Profession

All participants, either working as practitioners in the construction industry or in the academy as researchers or teaching staff, were chosen for their professions which were closely related with the issue of BIV. The group of professionals with the highest percentage was *Architects* with 30%, followed by *Landscape Designers* with 17%. *Civil Engineers* and *Urban Designers* followed them with each having 15%. *Planning Engineers, Investors*, and *Agronomists* followed these professions with lower percentages, as shown in Figure 1.

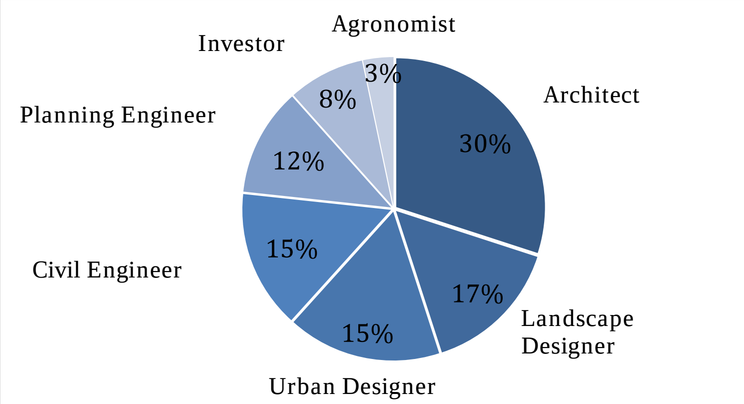

Figure 1. Professions of the participants

Work experience

These should be a The work experience of the participants varied as nearly half of them possessed an experience of 5 to 10 years, while 25% had less than 5, 18% had 11-15 and 10% had more than 15 years of experience (Figure 2). Regarding the number of construction projects contributed by the participants, the majority of them (40%) took part in 5-10 projects, while 30% joined less than 5, 23.3% joined around 10-20 and 6.7% contributed to 20 or more projects (Figure 3). Thus, it can be noted that all participants had significant work experience considering their time spent in the business and the number of projects they were involved in. Furthermore, a significant portion of the participants (77%) had taken roles in the design and construction stages of green roof, green wall and interior garden applications in buildings (Figure 4). Therefore, the participants were regarded as qualified professionals for the conducted survey, in determining the critical aspects, the motivators and the barriers of BIV.

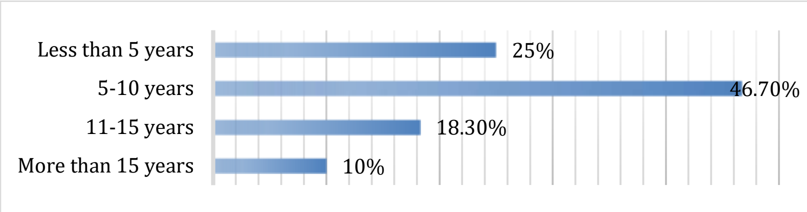

Figure 2. Number of years of work experience

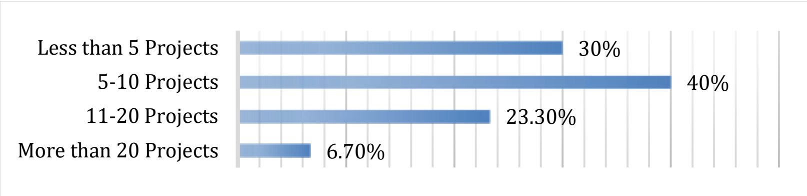

Figure 3. Number of projects contributed by the participants

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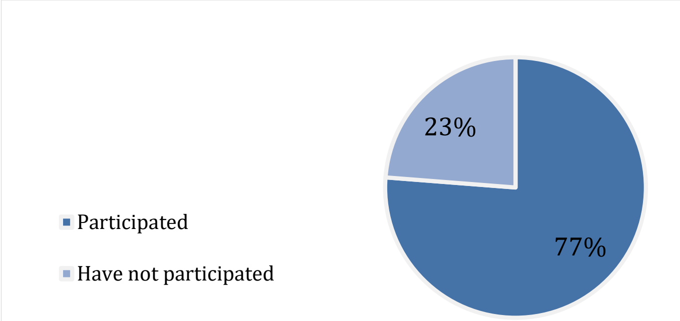

Figure 4. Participation in projects including Building-Integrated Vegetation

Critical Aspects of BIV

Different construction methods

A significant portion of the professionals support that there is greater opportunity in integrating vegetation into building elements if the structure is made of concrete. This finding can be linked with the fact that concrete structures are more resistant to humidity and loads (Franco *et al*, 2012; OCCDC, n.d.). 86% of the participants support that BIV is easily applicable in steel structures, while in timber frame structures it is seen as may not be possible (Figure 5). It should be noted that, considering the resistance of structural systems, differing BIV systems which vary in characteristics and methods of application provide various alternatives for designers. Moreover, the correct design of green roofs and green walls require detailed examinations and calculations by structural engineers to provide proper load bearing systems in buildings. This finding underlines the importance of a collaborative work on BIV applications (Brennek and Yuen, 2013; Clark, 2008; Hui, 2011; Shackell and Walter, 2012; Sharp *et al*, 2008; Wong and Baldwin, 2016).

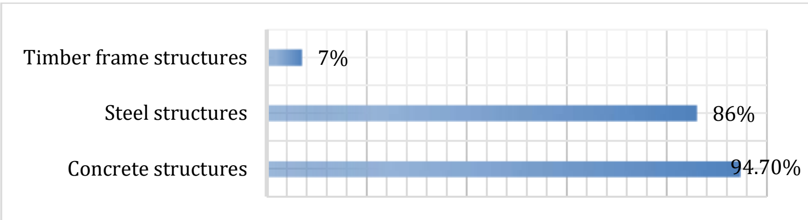

Figure 5. The ease of applying BIV for different construction methods

Significance order for types of buildings and professions

As to the order of significance for applying BIV in various buildings types, health care buildings were found to be having a priority considering the issue, by a majority of the participants. This finding can be linked with the positive effects of plants on the physical and mental health of patients and their visitors, proved by studies which encourage integrating vegetation in this building typology (Hartig and Cooper Marcus, 2006; Shackell and Walter, 2012). In the significance order, hospitality and commercial buildings were ranked second and third respectively. As the daily operational energy consumption and user densities are relatively higher in these types of buildings, they are considered as types that should benefit more from such sustainable applications (Bjerre, 2011; Tassicker *et al*, 2016). Moreover, residential building typology was ranked fourth in the above-mentioned order of significance. This result is found to be consistent with the findings of a study conducted by Stand and Peck (2017), about applications of green walls in different building types in USA. In the mentioned study, it was found that residential buildings find less chance to integrate vegetation due to the relatively high costs of these applications. However, the results on the level of importance of institutional buildings differ, since the participants of our study ranked them as having less importance, while the research of Stand and Peck found this type to be the most important (Stand and Peck, 2017). The significance order according to the respondents of our study, regarding the application of BIV in different types of buildings can be seen in Figure 6.

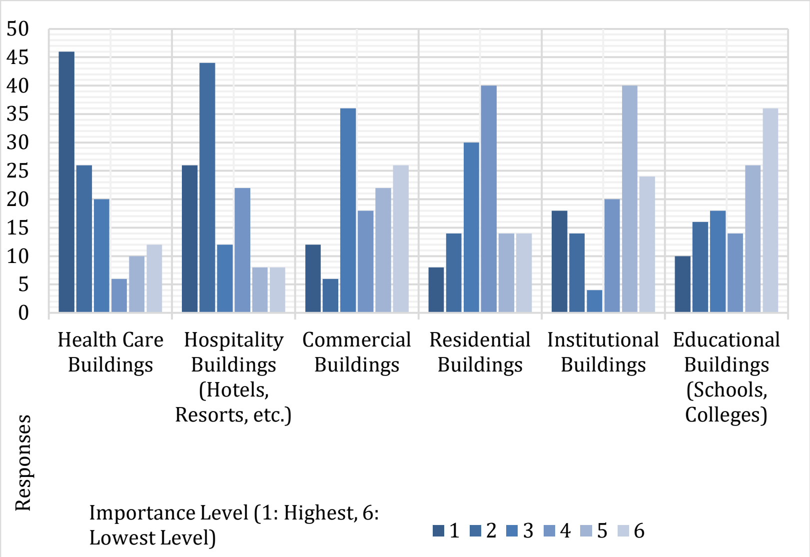

Figure 6. Significance order for the application of BIV in different types of buildings

Furthermore, based on their order of significance in management and implementation of these applications, professions which are related to BIV were ranked. The descending order of significance was found as, the architect, followed by environmental engineer, landscape designer, urban planner, civil engineer, project owner, financial expert and information technologist (Figure 7). Since the architect is responsible of organizing and directing how each branch of expertise works in a project, it is regarded as the most crucial profession considering this issue.

DOI: 10.15320/ICONARP.2020.107 E-ISSN: 2147-9380

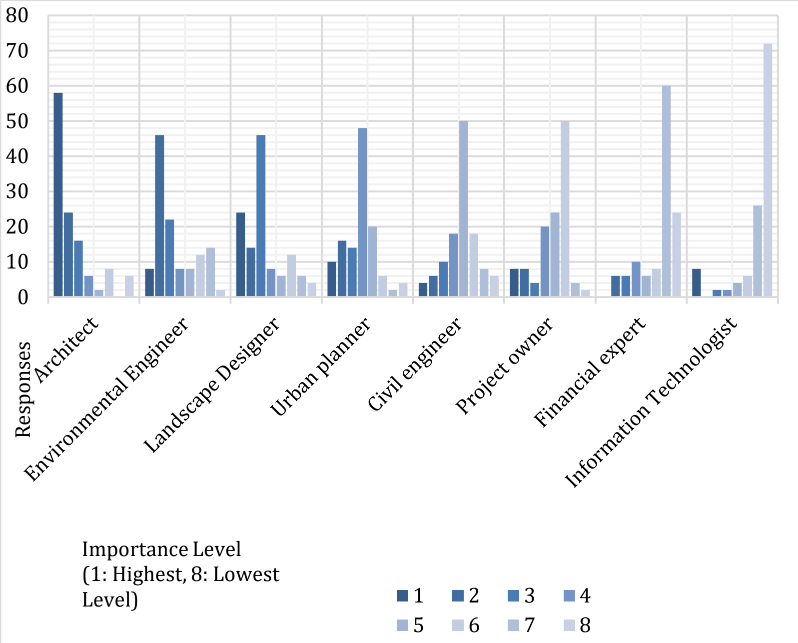

Figure 7. Significance order of professions in the management and implementation of BIV

Regarding the design of structures capable of withstanding large loads of green roofs, nearly two-thirds of the respondents supported that it was 'definitely possible', while 33.3% stated that it was 'possible to a certain extent' (Figure 8). Hence, provided that live and dead loads such as rain, wind and growth medium are studied and, the sizes and loads of plants are estimated based on their future growth (Hui, 2011; Lawlor, 2006; Miklos, 1998; Ottelé *et al*, 2011), the issue of large loads does not constitute a strict barrier for the application processes of BIV in new buildings.

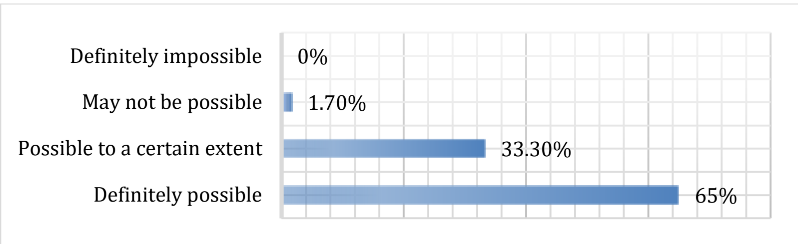

Figure 8. Possibility of designing structures withstanding large green roof loads

Applications in historical buildings

Another criterion that was assessed is related to the possibility of applying BIV in historical buildings. Majority of the participants supported that this issue was 'possible to a certain extent', depending on the structural conditions of the buildings and the types of BIV elements. 20% of the respondents stated that it was 'definitely possible', while a similar percentage considered it not possible (Figure 9). A report published by the United State General Services Administration in 2011, pointed out that some historical buildings with BIV had durable, high quality, well-engineered structures. Hence, these buildings

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offered solid opportunities in the implementation of BIV (USGSA, 2011). Moreover, National Gardens Service of U.S. Department of the Interior published guidelines for the rehabilitation of historical buildings. In this study, the criteria to be considered in the implementation of green roofs in historical buildings were given (Grimmer *et al,* 2011). Therefore, it can be stated that the responses of the participants showed parallel results with the literature regarding this issue.

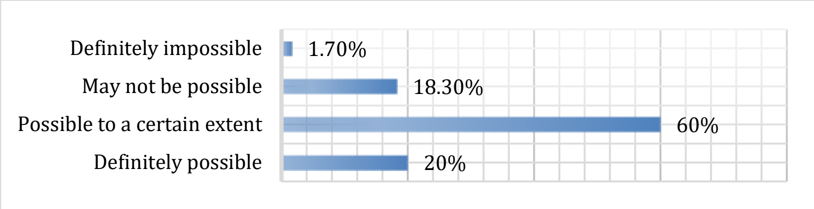

Figure 9. The possibility of implementing BIV in historical buildings

Contribution to energy efficiency

Moreover, more than two-thirds of the participants stated that BIV contribute to energy efficiency and reducing costs in buildings, which is coherent with the findings of the study of Charoenkit and Yiemwattana (2016) (Figure 10). It can be seen that these results are highly consistent with previously mentioned studies, and indicate a high level of awareness of the respondents regarding the benefits of BIV.

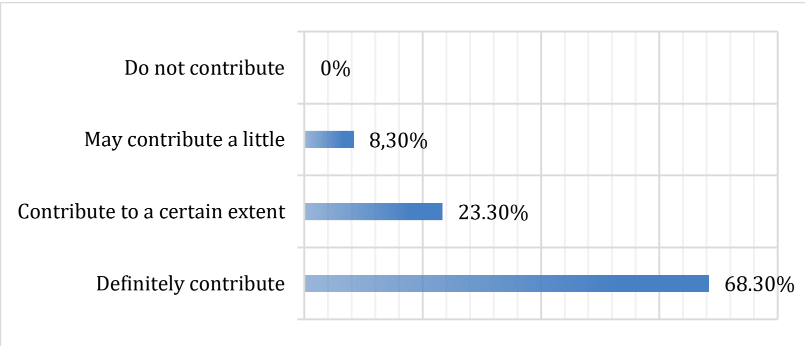

Figure 10. Contribution of BIV to energy efficiency and reducing costs

Motivators and Barriers of BIV

As a result of in-depth and extensive studies on the literature regarding the issue of BIV, the *motivator* and *barrier* factors were determined. After that, these factors were asked to be assessed by the participants of the study as to what degree they would affect the implementation of these applications (Figure 11).

Motivators of BIV

The following factors were determined as *motivators that affect the applications of BIV* by the participants of our study:

- Help reduce the effects of climate change (Zupancic *et al*, 2015; Stand and Peck, 2017).

DOI: 10.15320/ICONARP.2020.107 E-ISSN: 2147-9380

- The interest of owner/investor/institution (Gündoğan, 2012).
- Long term economic savings (Sutton, 2013).
- The awareness and interest of decision makers (i.e. environmental protection organizations, governmental authorities, etc.) (Liu *et al*, 2012; Gündoğan, 2012).

Motivators which *strongly affect the applications of BIV* are as follows:

- Improving indoor air quality. (Lee and Maheswaran, 2011; Pugh *et al*, 2012; Brennek and Yuen, 2013).
- Providing thermal and sound insulation for buildings (Wong and Baldwin, 2016; Charoenkit and Yiemwattana, 2016; Victorero *et al*, 2015).
- Providing the feeling of relief for building occupants (Shackell and Walter, 2012; Stand and Peck, 2017; Loh, 2008).
- Providing energy efficiency (Clark, 2008; Elston, 2000).
- Protection of the environment (Charoenkit and Yiemwattana, 2016; Wong and Baldwin, 2016).
- The awarded certificates for green buildings (Stand and Peck, 2017).
- The support of governments for sustainable projects (Clark, 2008; Bjerre, 2011; Larson, 2016).
- Increasing biodiversity (Loh, 2008; Engleback *et al*, 2003; Brenneisen, 2003; Clark, 2008).

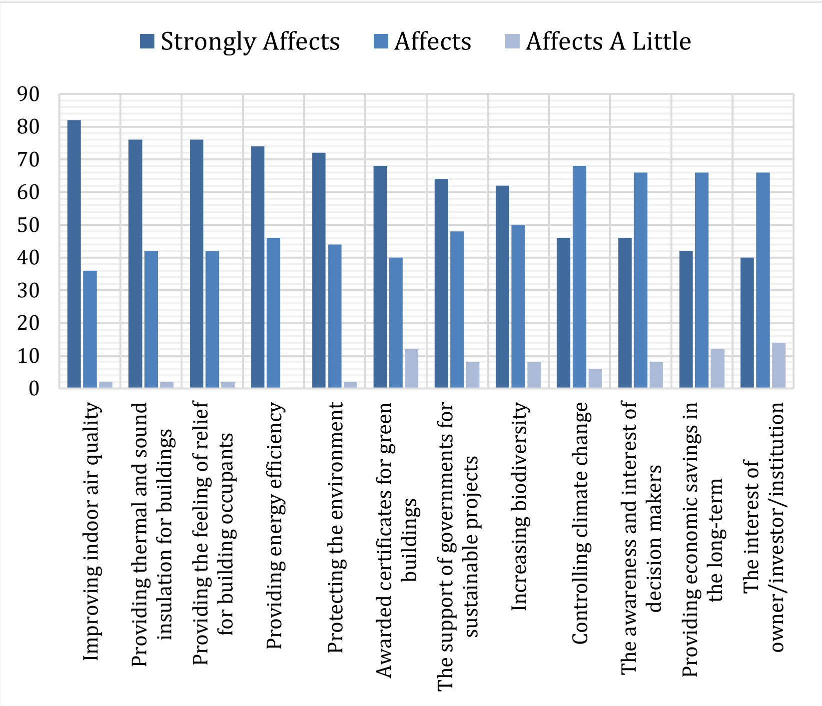

Figure 11. The effects of motivators of BIV applications

Barriers of BIV

According to the participants the *barriers that affect BIV applications* are:

- Lack of proper market (Gündoğan, 2012).
- Lack of specialized professionals (Gündoğan, 2012).
- Difficult climatic conditions (Hui, 2011).
- Frequent maintenance requirements (Sharp *et al*, 2008; Elgizawy, 2016).
- Lack of governmental tax incentives (Clark, 2008; Bjerre, 2011).

Moreover, as to the findings of our study, the following factors are determined as *barriers that strongly affect BIV applications*:

- Lack of awareness among stakeholders (Gündoğan, 2012).
- Lack of modern management skills (Gündoğan, 2012).
- Lack of knowledge (Bjerre, 2011).
- High initial cost (Bjerre, 2011; Tassicker *et al*, 2016).
- Lack of demand by the user/client (Tassicker *et al*, 2016).
- Lack of proper regulations (Gündoğan, 2012).

(Figure 12)

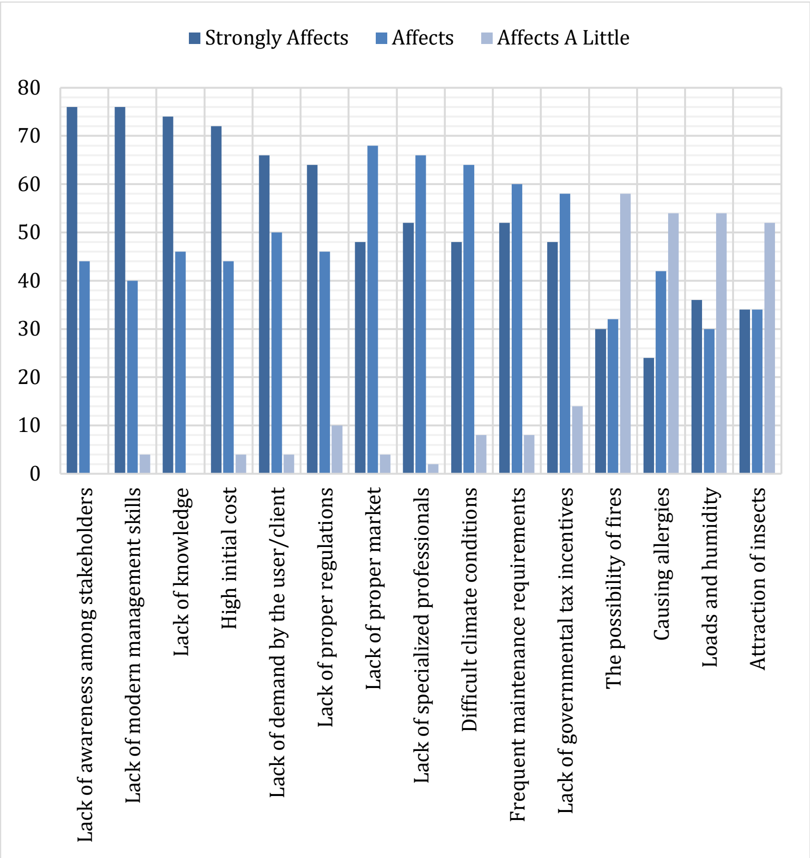

Figure 12. The effects of barriers of BIV applications

DOI: 10.15320/ICONARP.2020.107 E-ISSN: 2147-9380

A significant part of these results show consistency with the findings of other studies in literature, since 'lack of proper market and demand by the user', the 'lack of incentives from governmental and industrial bodies', 'high initial cost' and the 'lack of knowledge of their benefits' were found to be strongly affecting their applications (Bjerre, 2011; Tassicker *et al*, 2016). On the other hand, even though the possibility of starting fires was assessed as a barrier factor by some participants, studies in literature have shown that there are no fire risks associated with green roofs. As a matter of fact, some green roofs and green walls are built to provide fire resistance (FLL, 2002). Hui stated that "there is evidence suggesting that green roofs can help slowing the spread of fire to and from the building through the roof" (Hui, 2011) (p.4). Moreover, considering the effects of difficult climatic conditions on BIV applications, there are contradicting results between the findings of our questionnaire and the conducted literature review, as most of the participants supported that difficult climatic conditions can affect these applications. On the contrary, Sharp *et al.* (2008) states that green walls can be safely and successfully applied in a number of climate types (Sharp *et al*, 2008). Additionally, in the study of Sadeghian it is mentioned that "a green wall can be built outside (green facade, living wall) or inside a building cover, in a variety of countries and under various weather conditions" (Sadeghian, 2016, p.50). Also in their study, Timur and Karaca support this point of view by stating "green walls perform well in various climate environments. However, the selection of better species may adapt to the prevailing climatic condition" (Timur and Karaca, 2013, p.592). It should also be noted that, other studies have also underlined the importance of selecting the suitable plants capable of withstanding high temperatures and drought, such as local plants that can adapt themselves to difficult climatic conditions and keep growing for several years (Elliot, 2008; Li and Yeung, 2014; Perry, 2010).

Future Possibilities of BIV

Effects of professions on future developments

As to the effect of professions considering the promotion of BIV applications in future developments, respondents pointed out that the architect occupies the first place with respect to importance. Respectively; interior designer, developer, investor, building owner, building user and contractor follows this profession in the order of significance for this issue (Figure 13).

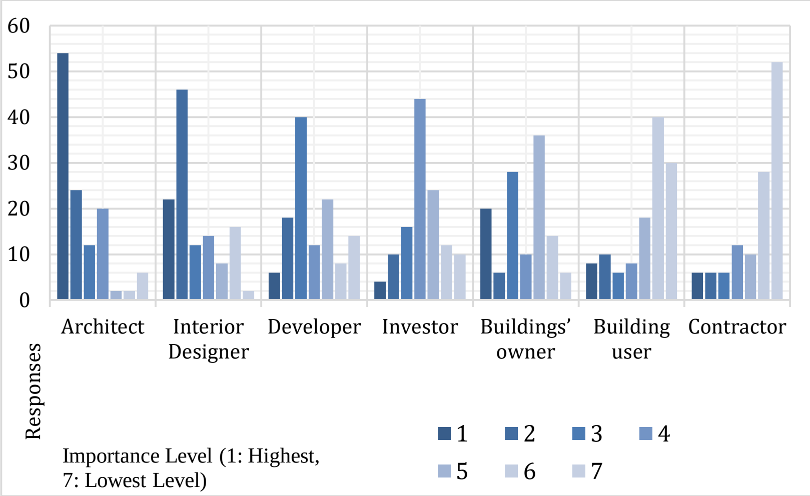

Figure 13. Effect of professions related to promoting BIV applications on future developments

The study of Wilkinson *et al.* (2015) which involved a smaller scale survey on green roof applications and targeted stakeholders in Sydney in 2012, found that in order to encourage their widespread applications, a great deal of pressure lies on architects and designers because of their capabilities of using BIV in their projects (Wilkinson *et al*, 2015). The findings of our study are parallel to the results of Wilkinson *et al.* (2015) and Anderson's studies, as it was found that the responsibility to convince the client towards the application of such projects relies heavily on the architect and interior designer (Anderson, 2004; Wilkinson *et al*, 2015). However, the study of Tassicker *et al*, conducted for Australia in 2016 stated that a major responsibility lies on the client (Tassicker *et al*, 2016).

On the other hand, it should also be noted that each and every mentioned profession is held responsible for providing certain strategies in their areas to solve the related environmental, social and economic problems of construction processes. Moreover, the collaborative work of diverse professions would promote the implementation of sustainable design approaches in building projects.

Motivator factors for future applications of BIV

The participants revealed that the most important motivator factor for the implementation of BIV in future applications is 'the dissemination of related studies', which implies the significance of the need to increase the level of knowledge and awareness on the issue. Moreover, the dissemination of related studies can help eliminate some barriers and increase the number of innovative applications regarding the mentioned issue. Therefore, the accumulation of such local, national and international studies constitutes an essential opportunity for researchers and practitioners to have a full comprehension of

DOI: 10.15320/ICONARP.2020.107 E-ISSN: 2147-9380

the issue of BIV. Furthermore, studies on its economic aspects would contribute to reducing its costs in the future.

The participants also pointed out that 'financial or moral support from effectual institutions' has an important role in promoting BIV applications. This support can be performed in the forms of loans, grants or discounts. These green incentives were implemented in several countries, such as Japan, USA and the U.K., and were well received by investors. Another motivational factor can be associated with green building rating tools, such as LEED and BREEAM, as these tools give certain points for BIV applications in the assessment of projects. BIV applications would help the assessed buildings get certified and receive higher rates.

Our study pointed out that 'increasing awareness on environmental problems' is also an important motivator. However, it should also be noted that, for the application of sustainable projects, the study of Wilkinson *et al.* (2015) found most environmental motivators to be less important than economic and social motivators. Finally, responses indicated that relatively less important motivators were; 'providing necessary materials in the local market', and 'having regulations and policies for the applications of such projects' (Figure 14).

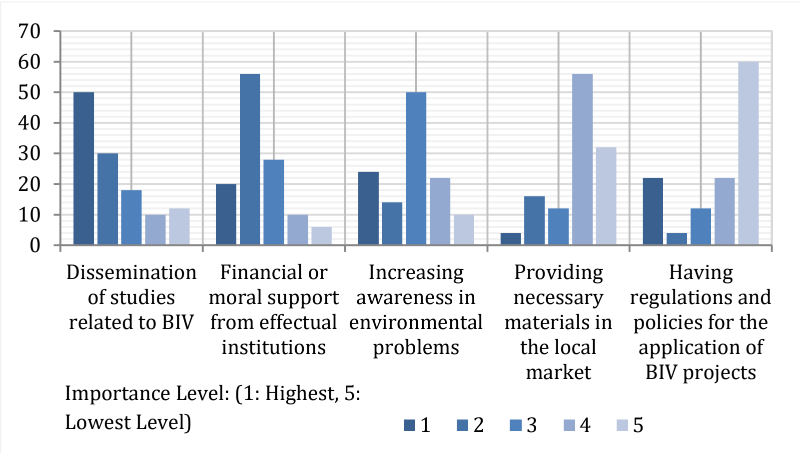

Figure 14. Significance of motivator factors for future BIV applications

Discussion and Further Studies

As stated above, the case countries for the questionnaire survey conducted in this study was selected to represent diverse climatic and regulatory conditions across the globe. Therefore, the results of the questionnaire were evaluated as a whole, by taking all answers of the participants as one sample group. However, to see if there was a significant difference or a rather more uniform distribution of rankings on the motivators and barriers of BIV among the four case countries, further research was conducted. Based on the responses, it was seen that among the four case countries, there was significant difference among certain factors regarding the motivators and barriers of BIV assessed in the present study. For instance, participants from Canada showed relatively higher rankings on certain motivator factors compared to other countries' distributions. These are:

- The interest of owner/investor/institution
- The awareness and interest of decision makers (i.e. environmental protection organizations, governmental authorities, etc.)
- The awarded certificates for green buildings
- The support of governments for sustainable projects

Moreover, Malaysia showed a significant difference in the factor; 'The interest of the owner/investor/institution', and Turkey displayed a significant difference in the factor; 'The awarded certificates for green buildings', among the ranking distributions of presented motivators.

On the other hand, as to the barriers it was seen that Libya showed a significant difference in the rankings of the following factors:

- Lack of proper market
- Lack of specialized professionals
- Difficult climatic conditions
- Lack of governmental tax incentives
- Lack of proper regulations

Moreover, while the highly ranked barriers which showed significant difference for Turkey were 'Lack of proper market' and 'High initial cost', the only significantly different barrier for Canada was found to be 'Difficult climatic conditions'.

Therefore, based on these findings it was derived that rather than the climatic differences, the regulatory differences played more significant role in the distribution of rankings as to the differences among the four case countries. It can be conveyed that these rather more highly ranked factors specific to the above-mentioned countries depend on their differences of development levels. Since Canada and Malaysia are more developed countries, the participants from these countries tend to have responses showing a higher state of awareness of the public and a more supporting governmental structure that provide suitable and promoting environments. However, as Libya is a developing country still having post-war struggles, the participants from this country highly rated barriers that show the difficult conditions faced to implement such applications in construction projects.

On the other hand, Turkey tends to display a more balanced state regarding motivator and barrier factors of BIV. According to the participants, green building certification is seen as an important motivator factor, while there also seems to be a lack of a

DOI: 10.15320/ICONARP.2020.107 E-ISSN: 2147-9380

productive environment as to its market for these applications. Turkey is still a developing country, however there is a significant amount of construction activities, both with and without the pursuit of green building certifications. Hence, the highly rated barriers for this country are believed to be associated with its financial drawbacks in the economy.

The barrier factor related to the difficult climatic conditions showed that, this factor was related to the relatively harsher climatic conditions of the two countries; Libya and Canada. It can be inferred that Turkey and Malaysia provide the ease of a more suitable environment for these applications, regarding their milder (Turkey) and more humid (Malaysia) climates.

Furthermore, in order to specifically determine the climatic and regulatory conditions that affect the motivator and barrier factors of BIV in the selected case countries, further studies can be conducted with the help of semi-structured interviews and/or open-ended questions. Following the present study, a separate research with the mentioned aim is considered to be conducted in the future.

CONCLUSION

It is evident that there is a vital need to propose and implement solutions to the problems of global excessive energy use and increasing levels of air pollution (Daly and Zannetti, 2007) Regarding these problems, BIV applications offer a remedy as they regulate air temperatures, act as insulators for the buildings and filter the pollutants in air. With this study, the opinions of decision makers and the influential figures involved in the implementation of BIV were gathered to determine the critical aspects, as well as the motivators and barriers of the application. Therefore, the participants of our study included a wide variety of professionals from various countries representing different climatic, geographic and regulatory conditions across the globe. Academicians of architecture-related fields and practitioners in the construction industry, have significant responsibility for promoting and implementing BIV applications, to increase awareness in these issues and fight the above-mentioned problems.

As to the findings of the study, healthcare buildings were given the first priority among the building types for applying BIV. Hospitality and commercial buildings followed this type owing to their high user capacities. Regarding the motivator factors for the application, besides the environmental, social and economic benefits of BIV, helping to receive green building certification was found to be an important incentive.

Moreover, for overcoming particularly, the highly rated barriers of; the 'lack of proper regulations' and 'lack of demand by the user/client', the support and adoption of decision makers and authorities for the mentioned applications are needed. Governmental and non-governmental, as well as, profit and non-profit organizations should seek to increase the level of awareness in communities regarding energy consumptions and air pollution together with their negative effects on health.

Yet, responses have shown that the highest responsibility for the execution, management, and promotion of these applications is on the architect. Therefore, the importance of such issues should be strongly emphasized in educational programs on architecture. Furthermore, specialized professional teams composed of architects, interior designers, engineers and agronomists should be trained to be experts on BIV applications. Architects should persuade investors to integrate these applications in the designs of their buildings, despite their high initial costs, since they will redeem their costs by providing lower heating and cooling loads in the long term. In addition to these, the market for the construction industry should be developed to provide the required materials and the production of these materials should be at local scales.

To sum up, it is a well-known fact that projects with BIV outperform traditional buildings in terms of their economic, social, and environmental performances (Loh, 2008; Tassicker *et al*, 2016). It can be stated that this green design approach represents a sound and feasible solution for overcoming certain environmental, economic and health-related problems and helps the development of sustainable cities. To be able to achieve this, a collaboration of a wide range of disciplines and the incentives of governmental authorities are needed. Within this framework, it is expected that our study will help serve as a guide for the stakeholders to increase the application rates of BIV in the construction industry.

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DOI: 10.15320/ICONARP.2020.107 E-ISSN: 2147-9380