# A DECISION SUPPORT SYSTEM FOR THE SELECTION OF GREEN ROOF FOR RESIDENTIAL BUILDINGS

AMIR MAHDIYAR

UNIVERSITI TEKNOLOGI MALAYSIA

# A DECISION SUPPORT SYSTEM FOR THE SELECTION OF GREEN ROOF FOR RESIDENTIAL BUILDINGS

AMIR MAHDIYAR

A thesis submitted in fulfilment of the
Requirements for the award of the degree of
Doctor of Philosophy (Civil Engineering)

Faculty of Civil Engineering
Universiti Teknologi Malaysia

JUNE 2017

*This thesis lovingly dedicated to*
*my wife, Sanaz. Her support,*
*encouragement, and constant love have*
*sustained me throughout my life.*

## ACKNOWLEDGEMENT

First and above all, I praise God, the almighty for providing me this opportunity and granting me the capability to proceed successfully. This thesis appears in its current form due to the assistance and guidance of several people. I would therefore like to offer my sincere thanks to all of them.

My sincere thanks goes to my supervisors Assoc. Prof. Dr. Arham Abdullah and Dr. Mohammadreza Vafaei for the continuous supports of my Ph.D. study and related research, for their patience, motivation, and immense knowledge. Their guidance helped me in all the time of research and writing of this thesis.

My sincere thanks also goes to my beloved wife, Dr. Sanaz Tabatabaee. Her support, encouragement, quiet patience, and unwavering love were undeniably the bedrock upon which the past eight years of my life have been built.

Thanks for supporting me during my studies and urging me on. Mom and Dad, you are wonderful parents and wonderful friends. My dear sister, I could not ask for a better sister and friend. All of your continued support and urging after moving to Malaysia is deeply appreciated. Thanks for making me finish this thing.

## ABSTRACT

Green roofs have been installed as a sustainable approach for many years all around the world. There are myriad benefits for green roof installation in terms of private and public sectors such as energy saving, stormwater management, and carbon reduction. Furthermore, there are three types of green roofs with different levels of benefits and costs; however, there is lack of model, framework, or decision support system (DSS) to facilitate the process of decision making for selecting the optimum type of green roof. The aim of the research is to develop a DSS to determine the optimum type of green roof. The research was conducted on residential buildings due to the highest percentage of green roof installation among other building categories in Malaysia. Enhanced Fuzzy Delphi Method (EFDM) has been developed for this study as the approach for data collection, while Multi-Criteria Decision Making (MCDM) is adopted in order to develop the DSS. Moreover, Cybernetic Fuzzy Analytic Hierarchy Process (CFAHP) was also developed as the method used in MCDM. EFDM and CFAHP were developed due to the shortcomings of previous methods for the novelty in this research. A database was created for the DSS using EFDM, while CFAHP method was used for developing the DSS. Additionally, in terms of DSS evaluation, hypothetical examples were defined and after obtaining the results, multiple criteria approach was conducted to understand its level of effectiveness and efficiency. DSS evaluation has been conducted involving experts in the field of green roof. Finally, it was concluded that the DSS works well and can be utilized in construction industry in the design phase. The experts' feedbacks showed that the developed DSS is effective and efficient, and were satisfied with the performance of the DSS.

## ABSTRAK

Bumbung hijau telah dipasang sebagai pendekatan mampan selama bertahun-tahun di seluruh dunia. Terdapat pelbagai faedah dengan pemasangan bumbung hijau dalam sektor swasta dan awam seperti penjimatan tenaga, pengurusan air hujan, dan pengurangan karbon. Tambahan pula, terdapat tiga jenis bumbung hijau dengan tahap faedah dan kos yang berbeza; bagaimanapun, terdapat kekurangan model, rangka kerja, atau sistem sokongan keputusan (DSS) untuk memudahkan proses membuat keputusan untuk pemilihan jenis bumbung hijau yang optimum. Kajian ini bertujuan untuk membangunkan satu sistem sokongan keputusan untuk menentukan jenis bumbung hijau yang optimum. Skop kajian ini merangkumi bangunan kediaman kerana ia meliputi peratusan tertinggi pemasangan bumbung hijau di kalangan kategori bangunan di Malaysia. Kaedah *Enhanced Fuzzy Delphi Method (EFDM)* telah dibangunkan untuk kajian ini untuk pengumpulan data, manakala *Multi-Criteria Decision Making (MCDM)* diguna pakai dalam usaha untuk membangunkan DSS. Selain itu, *Cybernetic Fuzzy Analytic Hierarchy Process (CFAHP)* telah dibangunkan sebagai kaedah yang digunakan dalam MCDM. EFDM dan CFAHP telah dibangunkan kerana terdapat kelemahan dalam kaedah kajian sebelum ini. Pangkalan data telah dicipta untuk DSS menggunakan EFDM, manakala kaedah CFAHP telah digunakan untuk membangunkan DSS. Selain itu, dari segi penilaian DSS, contoh hipotetikal telah ditetapkam dan selepas mendapat keputusan, pendekatan pelbagai kriteria telah dijalankan untuk memahami tahap keberkesanan dan kecekapan. Penilaian DSS telah dilakukan dengan menggunakan beberapa pakar dalam bidang bumbung hijau. Akhirnya, boleh disimpulkan bahawa DSS berfungsi dengan baik dan boleh digunakan dalam industri pembinaan dalam fasa reka bentuk. Maklum balas daripada pakar menunjukkan bahawa DSS yang dibangunkan berkesan dan cekap, dan berpuas hati dengan prestasi DSS.

# TABLE OF CONTENTS

# LIST OF TABLES

## LIST OF FIGURES

# LIST OF ABBREVIATIONS

| | | |
|---|---|---|
| AHP | - | Analytic Hierarchy Process |
| ANP | - | Analytic Network Process |
| BREEAM | - | Building Research Establishment's Environmental Assessment Method |
| CABE | - | Commission Of Architecture And The Built Environment |
| CFAHP | - | Cybernetic Fuzzy Analytic Hierarchy Process |
| CI | - | Consistence Index |
| CR | - | Consistence RATIO |
| CTLA | - | Council Of Trees And Landscape Appraisers |
| DEA | - | Data Envelopment Analysis |
| DM | - | Decision Making |
| DSS | - | Decision Support System |
| EFDM | - | Enhanced Fuzzy Delphi Method |
| EGR | - | Extensive Green Roof |
| ELECTTRE | - | Elimination Et Choix Traduisant La Realite |
| FDM | - | Fuzzy Delphi Method |
| FSs | - | Fuzzy Sets |
| FwD | - | Fuzzy With Delphi |
| GA | - | Genetic Algorithm |
| GBI | - | Green Building Index |
| GST | - | Grey System Theory |
| HK-BEAM | - | Hong Kong Building Environmental Assessment Method |
| HOQ | - | House Of Quality |
| IGR | - | Intensive Green Roof |
| LEED | - | Leadership In Energy & Environmental Design |

| | | |
|---|---|---|
| MCDA | - | Multi-Criteria Decision Analysis |
| MCDM | - | Multi-Criteria Decision Making |
| MCS | - | Monte Carlo Simulation |
| MIVES | - | Modelo Integrado De Valor Para Evaluaciones Sostenibles |
| NPV | - | Net Present Value |
| PROMET | - | Preference Ranking Organization Method For Enrichment Of Evaluations |
| Semi-IGR | - | Semi-Intensive Green Roof |
| TFN | - | Triangular Fuzzy Number |
| TOPSIS | - | Technique For Order Of Preference By Similarity To Ideal Solution |
| UHI | - | Urban Heat Island |
| VIKOR | - | Vise kriterijumska Optimizacija I Kompromisno Resenje |

# LIST OF APPENDICES

# CHAPTER 1

# INTRODUCTION

## 1.1 Overview

Green Revolution is the main theme of the era in 21st century (Rahman *et al.*, 2013; Wu, 2014). Many scholars around the world, are investigating and promoting the importance of green revolution using green technology in order to reduce the impact of environmental issues. Global warming, urban heat island (UHI), high-energy demands, air pollution, and lack of green spaces are the most crucial environmental issues in urban areas (Costanzo *et al.*, 2015; Berardi *et al.*, 2014), while construction practices are recognized as one of the main contributors for environmental issues (Karteris *et al.*, 2016). Moreover, sustainable approaches are especially known to be as the contributors for energy saving and reduction of carbon emissions. As a result, these approaches have been introduced to reduce the adverse impacts on environment that created by the construction industry (Akadiri *et al.*, 2013; Alyami *et al.*, 2013; Lundholm and Peck, 2008).

Currently, considering the term "sustainability" in all aspects of construction industry is a crucial issue around the world, and governments have found the necessity of using sustainable approaches for the next generations. Green roof as a sustainable alternative of the conventional roof, is defined as the use of vegetation covering the roof of a building (Refahi and Talkhabi, 2015). Installing green roof among private and public sectors is increasing due to the fact of having multiple benefits (Claus and Rousseau, 2012). Many buildings in developed countries have used green roof as one of the solutions to increase green area along with its benefits. Moreover, green roofs are becoming a trend, especially in modern high-rise building's design in Kuala

Lumpur (Zahir *et al.*, 2014). From the beginning of installing green roof as an environmentally-friendly approach, different types with different construction details were used throughout the world (Kosareo and Ries, 2007). For instance, in Germany, around 14% of all flat roofs have adapted green roof (Zahir *et al.*, 2014), while extensive green roof (a light type) was installed more than the other types. However, in Malaysia, intensive green roof (a heavy type like roof garden) is currently the most popular type of green roof (Rahman *et al.*, 2013; Claus and Rousseau, 2012). There are significant differences in the benefits, costs, maintenance periods, and the plant types that can be planted in each type of green roof; however, all types of green roofs are recognized as a sustainable and environmentally-friendly type of roofs in comparison with conventional roofs.

Green roofs can partially compensate for the loss of green areas by replacing impervious surfaces, and developing urban bio diversity (Wu, 2014). As stated by Getter and Rowe (2006), in most urban areas, the roof surfaces are accounted for roughly 21 to 26 percent of the total areas; thus, the use of green roofs can increase the urban green area. “The Greening of Greater KL," initiated by Ministry of Federal Territories and Urban Wellbeing, aims at converting a total area of 150,000 $m^2$ of the conventional roofs to green roofs by 2020 (Zahir *et al.*, 2014). Literature indicates that green roof has lots of environmental, social, and economic benefits (Getter and Rowe, 2008; Rahman *et al.*, 2013; Vijayaraghavan, 2016). In addition, the use of green roof results in the construction of an energy-efficient building since this approach reduces the amount of energy consumed for air conditioning (Liu, 2014). The environmental condition of the area can be positively affected by green roofs in terms of issues such as mitigation of storm water (Wong and Jim, 2015; Mentens *et al.*, 2006; Stovin *et al.*, 2012), sequestration of carbon (Ismail *et al.*, 2012), reduction of flash flood (Wong and Jim, 2015), and the replenishment of greenery in the urban area (Wu, 2014; Brenneisen, 2006).

This research aims to identify the criteria affecting green roof type selection, and to develop a Decision Support System (DSS) to obtain the optimum type of green roof. Wrong decision regarding the selection of green roof’s type, results in waste of money and energy, and the DSS could help the designers and decision makers for green roof type selection. At the end of the research, the DSS would play the role of an assistant for the designers to select the optimum type of green roof for any building.

## 1.2 Background of Research

Lack of greeneries causes many adverse environmental impacts such as UHI, global warming, and air pollution and so on (Zahir *et al.*, 2014; Rahman *et al.*, 2013). A study showed that Kuala Lumpur's green areas have been reduced to 59.4% (around 14,386 hectare from its original 24,222 hectare of city area) (Yusof and Johari, 2012). Moreover, global warming and UHI effect impose a dual warming impact on cities (Silva *et al.,* 2016; Jim, 2015a). The global warming phenomenon has triggered the movement towards sustainability in Malaysian construction industry (Zahir *et al.*, 2014). On the other hand, construction industry destroys the green spaces and vegetation for the purpose of building construction (Bianchini and Hewage, 2012). Furthermore, most of the environmental issues have been originated from constructing non-environmentally friendly buildings. Consequently, as we cannot stop the construction of buildings, we do have to search for alternative solutions to improve the performance of the buildings, and a new balance is needed to be applied between economic and environmental concerns.

Green roof installation as a sustainable alternative for conventional roof construction initiates from 1960 in Germany. After that, an increasing trend can be seen in green roof installation in European and other countries such as U.S., Singapore, and Japan (Zhang *et al.*, 2015). Based on the location of the buildings and the project requirements, green roofs have been installed with different construction details and different types of plants. These different types of green roofs can be categorized into three major category namely extensive green roof, semi-intensive green roof, and intensive green roof (Catalano *et al.*, 2016).

In intensive green roofs, a thick layer of growing medium or substrate is applied, wherein a variety of plants can be grown, especially in cases that irrigation is available. It is noteworthy that, additional structural support is needed due to the heavy weight of substrate; thus, this type of green roof can be applied to the buildings considering additional structural support (Schrader and Böning, 2006; Nagase and Dunnett, 2010). Whereas, in case of extensive green roof, a thinner layer of substrate is applied, which is a relatively lightweight and thus in some cases little or even no additional structural support is needed. Therefore, this type of roofs is applicable to a wider range of buildings. This advantage, together with a lower need for irrigation and lower maintenance requirement, have led to a wider application of extensive green roofs. On the other hand, the extensive green roofs provide a harsh environment for plant growth with wide temperature fluctuations, limited water availability, and high exposure to solar radiation and wind, which causes a highly stressed environment for growing plants (Bianchini and Hewage, 2012). Extensive green roofs are used to increase the surface area covered by vegetation in big cities, whereby reduce the UHI effect, promote carbon dioxide sequestration, and increase bio diversity and urban-wildlife habitats (William *et al.*, 2016; Ondono *et al.*, 2016). Moreover, semi-intensive green roof is a simple intensive green roof. Semi-intensive green roof is introduced to cover the green roofs which cannot be categorized neither in extensive nor intensive green roofs. These green roofs have a thicker soil layer in comparison with extensive green roofs, while, the plant diversity in these roofs is limited compared to intensive green roofs. Furthermore, additional structural support is required for installing semi-intensive green roofs, and regular maintenance is also necessary.

It is worth mentioning that there are some differences in the cost of green roofs considering net present value and payback period. Mahdiyar *et al*. (2016) focused on all the private factors affecting probabilistic cost-benefit analysis of installing two types of green roofs in Kuala Lumpur including initial cost, property value, energy saving, O&M costs, lifespan, and the acoustic effect. NPV and payback period of green roof installation were analyzed through Monte Carlo simulation. After obtaining the results, it is concluded that installing an extensive green roof is a low-risk investment and owners benefit from installing extensive green roof with a low probability of loss. Furthermore, installing an extensive green roof is a long-term investment with a short term return in Kuala Lumpur. For intensive green roof, the payback period is longer than extensive green roof in Kuala Lumpur; however, it also can be considered as a short-term investment.

Using greeneries onto the buildings as a sustainable way (not as a source of a renewable-energy system) reduces energy consumption and addresses some environmental issues caused by construction industry. Although there are many proven private and environmental benefits of integrating greeneries to the buildings (Gargari *et al.*, 2016), there is still lack of knowledge on the significant criteria that should be considered throughout the process of decision making for green roof selection (Zhang *et al.*, 2012). Although there are lots of studies conducted in the field of green roof, and the characteristics of all types of green roofs are discussed in previous studies (Vijayaraghavan, 2016), it is rare to find a study focused on the criteria related to the selection of appropriate type of green roof. Financial and non-financial criteria are involved throughout the process of decision making for obtaining the optimum type of green roof. Moreover, due to the high number of effective criteria, it's not easy to find the optimum type of green roof for any building. The aim of green roof installation, location of the green roof, structural considerations, maintenance of the green roof and some other criteria are non-financial criteria affecting the decision making. Considering all these criteria is a complicated process for decision making. Additionally, there are some significant financial criteria that play a critical role during this process. Consequently, all these criteria have to be taken into account in order to obtain the optimum result during the process of decision making for green roof type selection.

## 1.3 Problem Statement

There is an increasing trend of implementing green roof instead of conventional one. This growing trend is not just for aesthetic perspective rather for the positive environmental impacts (Gabrych *et al.*, 2016; Rahman *et al.*, 2013). Each type of green roof has its own advantages and disadvantages. Therefore, the purpose of having a green roof should be determined and understood before selecting the optimum type of green roof to meet the goal of any construction project. According to the recent paper written by Abdul Rahman *et al* (2013), installing each type of green roof in Malaysia has been based on the professional's intention. As reported, some professionals in Malaysia, select intensive green roof because they consider only the benefit of aesthetic, and guess that intensive green roof is more beneficial in comparison with other green roof types. Moreover, some of the other professionals select extensive green roof due to the lower required maintenance. However, different types of green roofs provide different costs and benefits (Jaffal *et al.*, 2012). The cost of intensive green roof installation is higher than the other types; however, it may not necessarily result in significant benefit for the client. As a result, there must be no allowance for guesswork by the designer's team because it can only lead to wrong specification or costly mistakes. Consequently, all effective criteria in decision making for green roof type selection have to be identified and considered during the process of decision making.

On the other hand, a semi-structured interview with the green roof contractors (with more than 21 years of experience) showed that, at the design stage of green roof installation, only two questions are often asked, firstly, how much the budget of the client is, and secondly, what type of green roof the client wants to be installed. This implies that, although many studies have investigated the costs and benefits for each type of green roof, still a serious challenge exists at the design stage of green roof installation. According to Johnson and Gibson (2014), the discipline of design is the process of decision making; however, there is still lack of a system, framework or guideline for decision-making in terms of selecting the optimum type of green roof. As a result, there is a need to have a tool to assist the designers to find the most appropriate type of green roof for any building.

## 1.4 Research Questions

The main research question in this research that is needed to be addressed is:

"How to select the optimum type of green roof for any building?"

The main research question was extended into five more specific sub-questions, which included:

1. What types of green roofs exist for construction?
2. Is the cost of installing green roof the only criterion that needed to be considered during the selection of type of green roofs?
3. What are the influential criteria in selecting the most appropriate type of green roof for any building?
4. Is it possible to make a right decision without any decision making tool for green roof type selection?
5. How can one make sure that the developed system for decision making on green roof type selection is effective, usable, and efficient?

## 1.5 Aim and Objectives

The research has highlighted the research gap on lack of any model or framework for green roof type selection. Therefore, the aim of this research is to propose a decision support system in order to determine the optimum type of the green roof for a building. In order to achieve this aim following objectives have been determined:

1. To identify the major types of green roof and their characteristics;
2. To identify the significant criteria affecting decision making for the selection of green roof;
3. To develop a prototype decision support system to determine the optimum type of green roof;
4. To evaluate the effectiveness and efficiency of the prototype decision support system.

## 1.6 Scope and Limitations

Green roof installation carries a large number of private and environmental benefits that could be appropriate for any climate, especially in tropical climate with rainy weather (Jim, 2015a; Nagase and Dunnett, 2010). This research focuses on decision making for green roof type selection in green roof installation projects. The research was limited to Malaysia with high potential of green roof installation. There are many studies conducted on the green roof installation for residential buildings, due to the suitability of this building category for green roof installation, e.g. (Refahi and Talkhabi, 2015; Gabrych *et al.*, 2016; Nyuk Hien *et al.*, 2007; Jim, 2015b). Moreover, according to a recent study, residential buildings are one of the major building's category for green roof installation in Malaysia (Rahman *et al.*, 2013). As a result, this research focused on "residential buildings" category, and three hypothetical cases were selected in order to evaluate the developed prototype system. In addition, criteria related to this research were gathered from all available references; however, the experts for refining these criteria were selected from construction industry and academicians in Malaysia. This research focused on all the criteria and sub-criteria influencing the selection of optimum type of green roof in green roof installation projects. Figure 1.1 indicates the summary of the scope of this research.

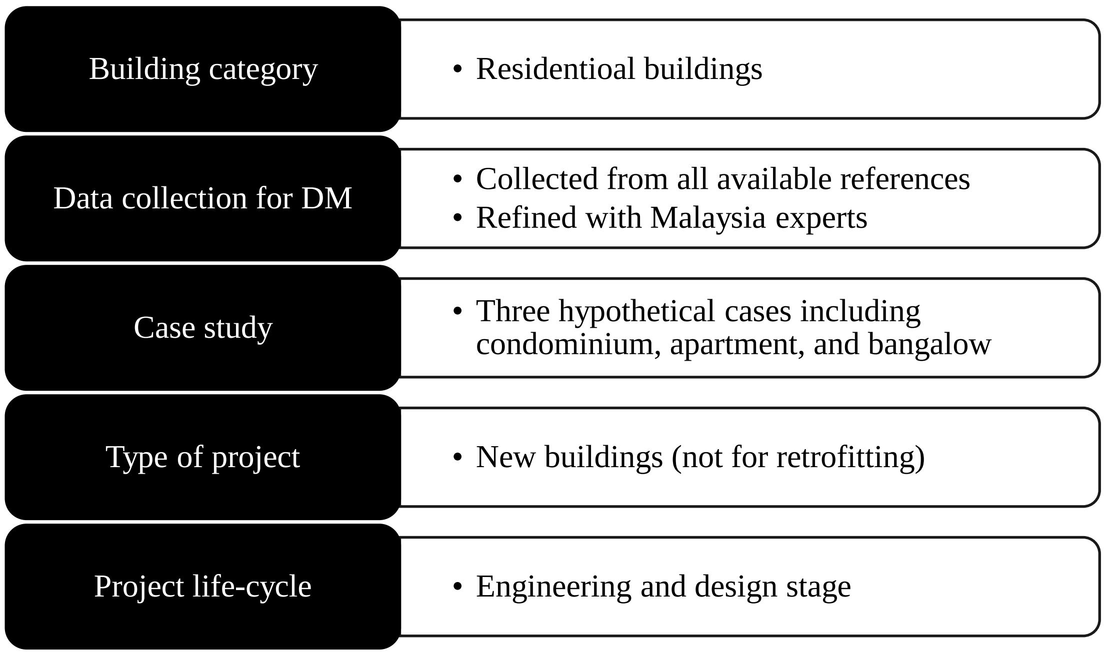


**Figure 1.1:** Research scope

## 1.7 Significance of Research

This research highlights three important aspects that would be achieved in this research, i.e. identifying the criteria affecting green roof type selection, giving a new insight to the green roof's type selection, and developing a decision support system for the selection of optimum type of green roof to prevent the waste of cost, energy and material.

Green roof type selection is the most critical decision that should be made at the design stage of a green roof installation project. Currently, there is lack of adequate knowledge among developers, contractors, and architects about the suitability of each type of green roof for different buildings' categories (Rahman *et al.*, 2013). Generally, the decision can be made by the project designer or green roof contractor; however, in some cases the client's idea is the priority for the decision making. Clients or even the designers are not aware of lots of benefits and some costs that green roofs offer, and in many cases, they just take care of the beauty and cost. The research gives a new insight to the designers by introducing all positive and negative aspects of green roof installation. A decision support system helps the designers and decision-makers to select the optimum type of green roof based on the project requirements. There are many criteria affecting decision making for green roof type selection such as application of green roof, project features and etc., and without a tool it is impossible to consider all these criteria and get an optimum result.

## 1.8 Thesis Outline

This thesis consists of seven chapters. The chapters were arranged according to the sequence of the objectives and rationale behind the research. **Chapter 1** formulates the proposal of the research. **Chapter 2** reviews all the related fields of studies have been conducted regarding green roof installation. All the criteria affecting decision making for green roof type selection were presented throughout this section as well. Moreover, different types of green roofs that can be installed, and their characteristics were described in detail. At the end of this chapter, the methods that have been used for developing a DSS in construction industry have been critically reviewed.

**Chapter 3** presents all the methodologies that have been used for this research. It begins with the preliminary studies, including reviewing the literature, semi-structured interviews and content analysis, followed by the main methodology of this research, multi-criteria decision making (MCDM). There are many criteria affecting DM for green roof selection; as a result MCDM was employed. Alternative formulation is the first step of MCDM, and the second step is criteria selection. Moreover, Enhanced Fuzzy Delphi Method (EFDM) was developed for this research as a method for criteria selection, while current methodologies for data collection were not appropriate for this research. In addition, in order to deal with the weaknesses of analytic hierarchy process (AHP), Cybernetic fuzzy AHP (CFAHP) was developed and discussed in the third step of MCDM for weighting the criteria and alternatives. At the end of this chapter, multi criteria evaluation approach was discussed in order to evaluate the prototype DSS.

**Chapter 4** presents the results and analyses of the research. It starts with alternative formulation followed by showing the results of criteria and sub-criteria identification. Then, the alternatives got weighted by the experts with respect to each sub-criterion that were identified during the process of EFDM. The results of this chapter were used as the material and the database for developing the prototype DSS.

**Chapter 5** presents the process of prototype development. It starts by the architecture of the software prototype, followed by the user requirements, and at the end, functional prototype was developed and discussed. Additionally, all the formulas that have been used for prototype system development were discussed.

**Chapter 6** evaluates the developed DSS through three cases from residential buildings. The priorities of the criteria were indicated based on the project requirements and the opinions of the users of the prototype DSS. Then the final results were presented including the optimum type of green roof for the cases as well as the most effective criterion and sub-criterion in the process of decision making. At the end of this chapter, the evaluation of the prototype DSS was presented and discussed regarding the efficiency, effectiveness, satisfaction, and use of the prototype system.

Finally, based on the objectives of the research, the conclusions derived from the research were presented in **Chapter 7**. Moreover, the recommendations for future works were highlighted throughout this chapter.

## REFERENCES


Abdullah, A. (2003). Intelligent selection of demolition techniques. Loughborough University. PhD thesis. University of Loughborough.

Akadiri, P. O., Olomolaiye, P. O., Chinyio, E. a. (2013). Multi-criteria evaluation model for the selection of sustainable materials for building projects. *Automation in Construction.* 30: 113–125. http://doi.org/10.1016/j.autcon.2012.10.004

Allnut, P., Bussey, W., Gedge, D., Harris, M., Henning, I., Poë, S., Zeller, S. (2014). The GRO Green Roof Code (Green Roof Code of Best Practice for the UK).

Alsup, S., Ebbs, S., Retzlaff, W. (2009). The exchangeability and leachability of metals from select green roof growth substrates. *Urban Ecosystems.* 13(1): 91–111. http://doi.org/10.1007/s11252-009-0106-y

Aly, A. M. (2013). Pressure integration technique for predicting wind-induced response in high-rise buildings. *Alexandria Engineering Journal*. 52 (4): 717–731. http://doi.org/10.1016/j.aej.2013.08.006

Alyami, S. H., Rezgui, Y., Kwan, A. (2013). Developing sustainable building assessment scheme for Saudi Arabia: Delphi consultation approach. *Renewable and Sustainable Energy Reviews.* 27: 43–54.

Anderson, M., Lambrinos, J., Schroll, E. (2010). The potential value of mosses for stormwater management in urban environments. *Urban Ecosystems.* 13 (3): 319–332. http://doi.org/10.1007/s11252-010-0121-z

Ascione, F., Bianco, N., de' Rossi, F., Turni, G., Vanoli, G. P. (2013). Green roofs in European climates. Are effective solutions for the energy savings in air-conditioning?. *Applied Energy*. 104: 845–859.

Banting, D., Doshi, H., Li, J., Missios, P., Au, A. (2005). Report on the environmental benefits and costs of green roof technology for the city of Toronto.

Begić, F., Afgan, N. (2007). Sustainability assessment tool for the decision making in selection of energy system—Bosnian case. *Energy*. 32 (10): 1979–1985. http://doi.org/10.1016/j.energy.2007.02.006

Berardi, U. (2016). The outdoor microclimate benefits and energy saving resulting from green roofs retrofits. *Energy and Buildings*. 121: 217–229. http://doi.org/10.1016/j.enbuild.2016.03.021

Berardi, U., GhaffarianHoseini, A., GhaffarianHoseini, A. (2014). State-of-the-art analysis of the environmental benefits of green roofs. *Applied Energy*. 115: 411–428. http://doi.org/10.1016/j.apenergy.2013.10.047

Bevilacqua, P., Mazzeo, D., Bruno, R., Arcuri, N. (2016). Experimental investigation of the thermal performances of an extensive green roof in the Mediterranean area. *Energy and Buildings.* 122: 63–79. http://doi.org/10.1016/j.enbuild.2016.03.062

Bianchini, F., Hewage, K. (2012a). How "green" are the green roofs? Lifecycle analysis of green roof materials. *Building and Environment*. 48: 57–65. http://doi.org/10.1016/j.buildenv.2011.08.019

Bianchini, F., Hewage, K. (2012b). Probabilistic social cost-benefit analysis for green roofs: A lifecycle approach. *Building and Environment*. 58: 152–162. http://doi.org/10.1016/j.buildenv.2012.07.005

Blackhurst, M., Hendrickson, C., Asce, D. M., Matthews, H. S., Asce, A. M. (2010). Cost-Effectiveness of Green Roofs. *Journal of Architectural Engineering*. 16 (4): 136–143.

Bojadziev, G., Bojadziev, M. (1997). Fuzzy logic for business, finance, and management. ($12^{th}$ ed.).

Brenneisen, S. (2006). Space for urban wildlife: designing green roofs as habitats in Switzerland. *Urban Habitats*. 4 (1): 27–36.

Carter, T., Keeler, A. (2008). Life-cycle cost-benefit analysis of extensive vegetated roof systems. *Journal of Environmental Management*. 87 (3): 350–63. http://doi.org/10.1016/j.jenvman.2007.01.024

Catalano, C., Marcenò, C., Laudicina, V. A., Guarino, R. (2016). Thirty years unmanaged green roofs: Ecological research and design implications. *Landscape and Urban Planning*. 149: 11–19.

Chan, A. P. C., Yung, E. H. K., Lam, P. T. I., Tam, C. M. (2010). Application of Delphi method in selection of procurement systems for construction projects. *Construction Management and Economics*. 19 (7): 699-718.

Chan, F. T. S., Ip, R. W. L., Lau, H. (2001). Integration of expert system with analytic hierarchy process for the design of material handling equipment selection system. *Journal of Materials Processing Technology*. 116 (2): 137–145. http://doi.org/10.1016/S0924-0136(01)01038-X

Chang, D. (1996). Applications of the extent analysis method on fuzzy AHP. *European Journal of Operational Research*. 95 (3): 649–655.

Chen, Z. (2010). A cybernetic model for analytic network process. *International Conference on Machine Learning and Cybernetics (ICMLC)*. 4: 1914–1919.

Chenani, S., Lehvavirta, S., Hakkinen, T. (2015). Life cycle assessment of layers of green roofs. *Journal of Cleaner Production.* 90: 153–162. http://doi.org/10.1016/j.jclepro.2014.11.070

Chong, H.-Y., Zin, R. M. (2010). A case study into the language structure of construction standard form in Malaysia. *International Journal of Project Management*. 28 (6): 601–608. http://doi.org/10.1016/j.ijproman.2009.09.008

Claus, K., Rousseau, S. (2012). Public versus private incentives to invest in green roofs: A cost benefit analysis for Flanders. *Urban Forestry Urban Greening*. 11 (4): 417–425. http://doi.org/10.1016/j.ufug.2012.07.003

Connelly, M., Hodgson, M. (2013). Experimental investigation of the sound transmission of vegetated roofs. *Applied Acoustics*. 74 (10): 1136–1143. http://doi.org/10.1016/j.apacoust.2013.04.003

Costanzo, V., Evola, G., Marletta, L. (2015). Energy savings in buildings or UHI mitigation? Comparison between green roofs and cool roofs. *Energy and Buildings*. 114: 247–255. http://doi.org/10.1016/j.enbuild.2015.04.053

Currie, B., Bass, B. (2008). Estimates of air pollution mitigation with green plants and green roofs using the UFORE model. *Urban Ecosystems*. 11 (4): 409–422.

Czemiel Berndtsson, J. (2010). Green roof performance towards management of runoff water quantity and quality: A review. *Ecological Engineering*. 36 (4): 351–360. http://doi.org/10.1016/j.ecoleng.2009.12.014

D'Orazio, M., Di Perna, C., Di Giuseppe, E. (2012). Green roof yearly performance: A case study in a highly insulated building under temperate climate. *Energy and Buildings*. 55: 439–451. http://doi.org/10.1016/j.enbuild.2012.09.009

de Vries, S., van Dillen, S. M. E., Groenewegen, P. P., Spreeuwenberg, P. (2013). Streetscape greenery and health: stress, social cohesion and physical activity as mediators. *Social Science Medicine* (1982). 94: 26–33.

Dinca, C., Badea, A., Rousseaux, P., Apostol, T. (2007). A multi-criteria approach to evaluate the natural gas energy systems. *Energy Policy*. 35 (11): 5754–5765.

Dinsdale, S., Pearen, B., Wilson, C. (2006). *Feasibility Study for Green Roof Application on Queen's University Campus*. (April) Queen's Physical Plant Services.

Dunnett, N., Nagase, A., Booth, R., Grime, P. (2008). Influence of vegetation composition on runoff in two simulated green roof experiments. *Urban Ecosystems*. 11 (4): 385–398. http://doi.org/10.1007/s11252-008-0064-9

Dvorak, B Green roofs in sustainable landscape design by Steven L. Cantor. *Landscape and Urban Planning*. 92 (3): 347-348

Elsayed, I. (2012). Mitigation of the urban heat island of the city of Kuala Lumpur, Malaysia. *Middle-East Journal of Scientific Research*. 11(11): 1602–1613.

ESI, 2017, *ESI Building Design* [Online]. Available at: https://www.buildingdesignindex.co.uk/entry/42588/TerraProducts/Sedum-green-roof-blanket/ [Accessed: 5 May 2017].

Fauzi, M. A., Malek, N. A., Othman, J. (2013a). Evaluation of Green Roof System for Green Building Projects in Malaysia. In *World Academy of Science, Engineering and Technology*. 7: 75–81.

Fauzi, M. A., Malek, N. A., Othman, J. (2013b). Evaluation of Green Roof System for Green Building Projects in Malaysia. *International Journal of Environmental, Ecological, Geological and Mining Engineering*. 7 (2): 53–59.

Forgionne, G. (1999). An AHP model of DSS effectiveness. *European Journal of Information Systems*. 8 (2): 95–106.

Gabrych, M., Kotze, D. J., Lehvävirta, S. (2016). Substrate depth and roof age strongly affect plant abundances on sedum-moss and meadow green roofs in Helsinki, Finland. *Ecological Engineering*. 86: 95–104.

Gargari, C., Bibbiani, C., Fantozzi, F., Campiotti, C. A. (2016a). Environmental Impact of Green Roofing: The Contribute of a Green Roof to the Sustainable use of Natural Resources in a Life Cycle Approach. *Agriculture and Agricultural Science Procedia*. 8: 646–656.

Gargari, C., Bibbiani, C., Fantozzi, F., Campiotti, C. A. (2016b). Simulation of the Thermal Behaviour of a Building Retrofitted with a Green Roof: Optimization of Energy Efficiency with Reference to Italian Climatic Zones. *Agriculture and Agricultural Science Procedia*. 8: 628–636.

Garrod, G. (2002). Social and environmental benefits of forestry phase 2: landscape benefits. *Forestry Commission, Centre for Research in Environmental Appraisal and Management*, University of Newcastle. Edinburgh.

GBI, 2016, Green Building Index [Online]. Available at: http://new.greenbuildingindex.org/faq.

Getter, K. L., Rowe, D. B. (2008). Media depth influences Sedum green roof establishment. *Urban Ecosystems*. 11 (4): 361–372.

Getter, K., Rowe, D. (2006). The role of extensive green roofs in sustainable development. *HortScience*. 41 (5): 1276–1285.

Getter, K., Rowe, D., Andresen, J. (2007). Quantifying the effect of slope on extensive green roof storm water retention. *Ecological Engineering*. 31: 225–231.

Gonzalez, A., Barr, V. (2000). Validation and verification of intelligent systems-what are they and how are they different? *Journal of Experimental Theoretical Artificial Intelligence*. 12 (4): 407–420.

Green Building Index. (2016). Retrieved from http://new.greenbuildingindex.org/faq

Haidar, A., Naoum, S., Howes, R., Tah, J. (1999). Genetic Algorithms Application and Testing for Equipment Selection. *Journal of Construction Engineering and Management*, 125 (1): 32–38.

Hallikainen, P., Chen, L. (2012). A holistic framework on information systems evaluation with a case analysis. *Leading Issues in ICT Evaluation*. 9 (2): 57–64.

Hallowell, M. R., Gambatese, J. A. (2010). Qualitative Research: Application of the Delphi Method to CEM Research. *Journal of Construction Engineering and Management*. 136 (1): 99–107.

Housing in Malaysia Teoalida Website. (2016). Retrieved from http://www.teoalida.com/world/malaysia/

Hsu, T., Yang, T. (2000). Application of fuzzy analytic hierarchy process in the selection of advertising media. *Journal of Management and Systems*. 7 (1): 1932

Hu, Z., Zhang, J. (2011). BIM- and 4D-based integrated solution of analysis and management for conflicts and structural safety problems during construction: 2.

Development and site trials. *Automation in Construction*. 20 (2): 167–180. http://doi.org/10.1016/j.autcon.2010.09.014

Ishikawa, A., Amagasa, M., Shiga, T. (1993). The max-min Delphi method and fuzzy Delphi method via fuzzy integration. *Fuzzy Sets and Systems*. 55 (3): 241–253.

Ismail, F., Yusuwan, N. M., Baharuddin, H. E. A. (2012). Management Factors for Successful IBS Projects Implementation. *Procedia - Social and Behavioral Sciences*. 68: 99–107. http://doi.org/10.1016/j.sbspro.2012.12.210

Jaffal, I., Ouldboukhitine, S.-E., Belarbi, R. (2012). A comprehensive study of the impact of green roofs on building energy performance. *Renewable Energy*. 43: 157–164. http://doi.org/10.1016/j.renene.2011.12.004

Jaskowski, P., Biruk, S., Bucon, R. (2010). Assessing contractor selection criteria weights with fuzzy AHP method application in group decision environment. *Automation in Construction*, 19 (2): 120–126.

Jato-espino, D., Castillo-lopez, E., Rodriguez-hernandez, J., Canteras-jordana, J. C. (2014). A review of application of multi-criteria decision making methods in construction. *Automation in Construction*. *45*: 151–162.

Jato-Espino, D., Rodriguez-Hernandez, J. (2014). A fuzzy stochastic multi-criteria model for the selection of urban pervious pavements. *Expert Systems with Applications*. 41 (15): 6807–6817.

Jia, J. (1998). Attribute weighting methods and decision quality in the presence of response error: a simulation study. Texas University.

Jim, C. Y. (2015a). Assessing climate-adaptation effect of extensive tropical green roofs in cities. *Landscape and Urban Planning*, 138: 54–70. http://doi.org/10.1016/j.landurbplan.2015.02.014

Jim, C. Y. (2015b). Diurnal and partitioned heat-flux patterns of coupled green-building roof systems. *Renewable Energy*. 81: 262–274.

Jim, C. Y., Peng, L. L. H. (2012). Weather effect on thermal and energy performance of an extensive tropical green roof. *Urban Forestry Urban Greening*, 11 (1): 73–85. http://doi.org/10.1016/j.ufug.2011.10.001

Johnson, A., Gibson, A. (2014). Sustainability in Engineering Design (1st edition.). Elsevier Inc.

Johnston, J., Newton, J. (2004). *Building Green: A guide to using plants on roofs, walls and pavements*. Landon Ecology Unit.

Kaklauskas, A., Zavadskas, E. K., Trinkunas, V. (2007). A multiple criteria decision support on-line system for construction. *Engineering Applications of Artificial Intelligence*. 20 (2): 163–175. http://doi.org/10.1016/j.engappai.2006.06.009

Karteris, M., Mallinis, G., Tsiros, E. (2016). Towards a green sustainable strategy for Mediterranean cities. *Renewable and Sustainable Energy Reviews*. 58: 510–525. http://doi.org/10.1016/j.rser.2015.11.098

Kazerouni Sadi, M. (2015). A Hybrid Model for Assessing the Quality Performance of Demolition Contractors. Universiti Teknologi Malaysia.

Keprate, A., Ratnayake, R. M. C. (2016). Enhancing offshore process safety by selecting fatigue critical piping locations for inspection using Fuzzy-AHP based approach. *Process Safety and Environmental Protection*. 102: 71–84. http://doi.org/10.1016/j.psep.2016.02.013

Kibert, C., Monroe, M., Peterson, A. (2011). *Working toward sustainability: ethical decision-making in a technological world*. Hoboken, New Jersey: John Wiley and Sons, Inc.

Kokogiannakis, G., Tietje, A., Darkwa, J. (2011). The role of Green Roofs on Reducing Heating and Cooling Loads: A Database across Chinese Climates. *Procedia Environmental Sciences*. 11: 604–610.

Kosareo, L., Ries, R. (2007). Comparative environmental life cycle assessment of green roofs. *Building and Environment*. 42 (7): 2606–2613. http://doi.org/10.1016/j.buildenv.2006.06.019

Krippendorff, K. (2004). Reliability in content analysis. *Human Communication Research*. 30 (3): 411–433.

Kuhn, M. E., Peck, S. S. W., Kuhn, M. E. (2003). *Design guidelines for green roofs*. Ontario Association of Architects.

Kuhn, M. E., Peck, S. W. (2003). Design guidelines for green roofs. City, 22.

Kuo, Y., Chen, P. (2008). Constructing performance appraisal indicators for mobility of the service industries using Fuzzy Delphi Method. *Expert Systems with Applications*. 35 (4): 1930-1939.

Lahdelma, R., Salminen, P., Hokkanen, J. (2000). Using multicriteria methods in environmental planning and management. *Environmental Management*. 26 (6): 595–605. http://doi.org/10.1007/s002670010118

Lamnatou, C., Chemisana, D. (2015). A critical analysis of factors affecting photovoltaic-green roof performance. *Renewable and Sustainable Energy Reviews*. 43: 264–280. http://doi.org/10.1016/j.rser.2014.11.048

Lazzarin, R. M., Castellotti, F., Busato, F. (2005). Experimental measurements and numerical modelling of a green roof. *Energy and Buildings*. 37 (12): 1260–1267. http://doi.org/10.1016/j.enbuild.2005.02.001

Li, X., Ouelhadj, D., Song, X., Jones, D., Wall, G., Howell, K. E., Pertin, E. (2016). A decision support system for strategic maintenance planning in offshore wind farms. *Renewable Energy*. 99: 784–799.

Liang, G., Wang, M. (1993). A fuzzy multi-criteria decision-making approach for robot selection. *Robotics and Computer-Integrated Manufacturing*. 10 (4): 267–274.

Linstone, H., Turoff, M. (1975). *The Delphi method: Techniques and applications*. United State of America: National Criminal Justice Reference Service.

Liu, M. M. (2014). Probabilistic prediction of green roof energy performance under parameter uncertainty. *Energy*. 77: 667–674.

Long, B., Clark, S. (2007). Selecting a green roof medium for water quality benefits. In *World Environmental and Water Resources Congress*. 1–10.

Lotfabadi, P. (2014). High-rise buildings and environmental factors. *Renewable and Sustainable Energy Reviews*. 38: 285–295.

Lundholm, J. T., Peck, S. W. (2008). Introduction: Frontiers of green roof ecology. Urban Ecosystems. 11 (4): 335–337. http://doi.org/10.1007/s11252-008-0070-y

MacIvor, J. S., Lundholm, J. (2010). Insect species composition and diversity on intensive green roofs and adjacent level-ground habitats. *Urban Ecosystems*. 14 (2): 225–241. http://doi.org/10.1007/s11252-010-0149-0

MacIvor, J. S., Lundholm, J. (2011). Performance evaluation of native plants suited to extensive green roof conditions in a maritime climate. *Ecological Engineering*. 37 (3): 407–417. http://doi.org/10.1016/j.ecoleng.2010.10.004

Magill, J. D., Midden, K., Groninger, J., Therrell, M. (2011). A History and Definition of Green Roof Technology with Recommendations for Future Research. Department of Plant, Soil, and Agricultural Systems in the Graduate School, Master of Science. Southern Illinois University Carbondale. Paper 91. http://opensiuc.lib.siu.edu/gs_rp/91

Mahdiyar, A., Abdullah, A., Tabatabaee, S., Mahdiyar, L., Mohandes, S. R. (2015). Investigating the Environmental Impacts of Green Roof Installation. *Jurnal Teknologi*. 76 (1): 265–273. http://doi.org/http://dx.doi.org/10.11113/jt.v76.3975

Mahdiyar, A., Tabatabaee, S., Sadeghifam, A. N., Mohandes, S. R., Abdullah, A., Meynagh, M. M. (2016). Probabilistic Private Cost-Benefit Analysis for Green Roof Installation: A Monte Carlo Simulation Approach. *Urban Forestry Urban Greening*. 20: 317–327. http://doi.org/10.1016/j.ufug.2016.10.001

Majid, A., McCaffer, R. (1997). Non-Exclusive Delay in Construction. PhD thesis. Loughborough University of Technology. UK.

Manu, P., Ankrah, N., Proverbs, D., Suresh, S. (2010). An approach for determining the extent of contribution of construction project features to accident causation. *Safety Science*. 48 (6): 687–692. http://doi.org/10.1016/j.ssci.2010.03.001

Mardani, A., Jusoh, A, Nor, Kh., Valipour, Alireza. (2015). Multiple Criteria Decision Making Techniques and Its Applications – A Review of the Literature from 2000 to 2014. *Economic Research-Ekonomska Istraživanja.* 28 (1):516-571.

Martens, R., Bass, B., Alcazar, S. S. (2008). Roof–envelope ratio impact on green roof energy performance. *Urban Ecosystems*. 11 (4): 399–408. http://doi.org/10.1007/s11252-008-0053-z

Maynard, S., Arnott, D., Burstein, F. (1995). DSS evaluation criteria: A multiple constituency approach. Department of Information System. Monash University. Melbourne. Australia.

Maynard, S., Burstein, F., Arnott, D. (2001). A multi-faceted decision support system evaluation approach. *Journal of Decision Systems*, 10 (3): 395–428.

McIntyre, L., Snodgrass, E. (2010). The green roof manual: a professional guide to design, installation, and maintenance. Timber Press.

Mentens, J., Raes, D., Hermy, M. (2006). Green roofs as a tool for solving the rainwater runoff problem in the urbanized 21st century? *Landscape and Urban Planning*. 77 (3): 217–226.

Minghat, A. D., Yasin, R. M., Udin, A. (2012). The application of the Delphi technique in technical and vocational education in Malaysia. *Internafional Proceedings of Economics Development and Research*. 30 (1): 259–264.

Mohammadi, F., Sadi, M. K., Nateghi, F., Abdullah, A., Skitmore, M. (2014). A hybrid quality function deployment and cybernetic analytic network process model for project manager selection. *Journal of Civil Engineering and Management*. 20 (6): 795–809. http://doi.org/10.3846/13923730.2014.945952

Molineux, C. J., Fentiman, C. H., Gange, A. C. (2009). Characterising alternative recycled waste materials for use as green roof growing media in the U.K. *Ecological Engineering*. 35 (10): 1507–1513.

Molineux, C. J., Gange, A. C., Connop, S. P., Newport, D. J. (2015). Using recycled aggregates in green roof substrates for plant diversity. *Ecological Engineering*. 82: 596–604. http://doi.org/10.1016/j.ecoleng.2015.05.036

Moon, J., Kang, C. (2001). Application of fuzzy decision making method to the evaluation of spent fuel storage options. *Progress in Nuclear Energy*. 39 (3-4): 345–351.

Moore, N. (2000). How to do research; the complete guide to design and managing research projects. London University.

Morgan, S., Celik, S., Retzlaff, W. (2013). Green Roof Storm-Water Runoff Quantity and Quality. *Journal of Environmental Engineering*. 139 (2): 471–478. http://doi.org/10.1061/(ASCE)EE.1943-7870.0000589.

Murray, T. J., Leo, L. P., Gigvh, J. P. van. (1985). A pilot study of fuzzy set modification of Delphi. *Human Systems Management*. 5 (1): 76–80.

Nagase, A., Dunnett, N. (2010). Drought tolerance in different vegetation types for extensive green roofs: Effects of watering and diversity. *Landscape and Urban Planning*. 97 (4): 318–327. http://doi.org/10.1016/j.landurbplan.2010.07.005

Nardini, A., Andri, S., Crasso, M. (2011). Influence of substrate depth and vegetation type on temperature and water runoff mitigation by extensive green roofs: shrubs versus herbaceous plants. *Urban Ecosystems.* 15 (3): 697–708. http://doi.org/10.1007/s11252-011-0220-5

Niu, H., Clark, C., Zhou, J., Adriaens, P. (2010). Scaling of economic benefits from green roof implementation in Washington, DC. *Environmental Science Technology*, 44 (11): 4302–8. http://doi.org/10.1021/es902456x

Nyuk Hien, W., Puay Yok, T., Yu, C. (2007). Study of thermal performance of extensive rooftop greenery systems in the tropical climate. *Building and Environment*. 42 (1): 25–54. http://doi.org/10.1016/j.buildenv.2005.07.030

Ondono, S., Martinez-Sanchez, J. J., Moreno, J. L. (2016). The composition and depth of green roof substrates affect the growth of Silene vulgaris and Lagurus ovatus species and the C and N sequestration under two irrigation conditions. *Journal of Environmental Management.* 166: 330–340.

Ondoño, S., Martínez-Sánchez, J. J., Moreno, J. L. (2016). The composition and depth of green roof substrates affect the growth of Silene vulgaris and Lagurus ovatus species and the C and N sequestration under two irrigation conditions. *Journal of Environmental Management*. 166: 330–340.

Osmundson, T. (1999). Roof gardens: history, design, and construction. WW Norton and Company.

Ouldboukhitine, S.-E., Belarbi, R. (2015). Experimental Characterization of Green Roof Components. *Energy Procedia*. 78: 1183–1188.

Palla, a., Gnecco, I., Lanza, L. G. (2009). Unsaturated 2D modelling of subsurface water flow in the coarse-grained porous matrix of a green roof. *Journal of Hydrology*. 379(1): 193–204. http://doi.org/10.1016/j.jhydrol.2009.10.008

Pan, N.-F. N. (2008). Fuzzy AHP approach for selecting the suitable bridge construction method. *Automation in Construction*. 17 (8): 958–965. http://doi.org/10.1016/j.autcon.2008.03.005

Pandey, S., Hindoliya, D. a., Mod, R. (2012). Artificial neural network for predation of cooling load reduction using green roof over building in Sustainable City. *Sustainable Cities and Society*. 3: 37–45. http://doi.org/10.1016/j.scs.2012.01.003

Parkins, K. L., Clark, J. A. (2015). Green roofs provide habitat for urban bats. *Global Ecology and Conservation*. 4: 349–357.

Patton, M. (1982). Practical evaluation. SAGE Publications, Incorporated.

Peck, S., Callaghan, C., Kuhn, M., Bass, B. (1999). Greenbacks from green roofs: forging a new industry in Canada. Canada Mortgage and Housing Corporation (CMHC).

Peck, S. W., Kuhn, M. E. (1999). Greenbacks from Green Roofs: Forging A New Industry in Canada. Canada Mortgage and Housing Corporation (CMHC).

Peng, L. L. H., Jim, C. Y. (2015). Economic evaluation of green-roof environmental benefits in the context of climate change: The case of Hong Kong. *Urban Forestry Urban Greening*. 14 (3): 554–561. http://doi.org/10.1016/j.ufug.2015.05.006

Pérez, G., Coma, J., Solé, C., Castell, A., Cabeza, L. F. (2012). Green roofs as passive system for energy savings when using rubber crumbs as drainage layer. *Energy Procedia*. 30: 452–460. http://doi.org/10.1016/j.egypro.2012.11.054

Peri, G., Traverso, M., Finkbeiner, M., Rizzo, G. (2012). The cost of green roofs disposal in a life cycle perspective: Covering the gap. *Energy*. 48 (1): 406–414. http://doi.org/10.1016/j.energy.2012.02.045

Perini, K., Rosasco, P. (2013). Cost–benefit analysis for green façades and living wall systems. *Building and Environment*. 70: 110–121. http://doi.org/10.1016/j.buildenv.2013.08.012

Phillips-Wren, G. E., Hahn, E. D., Forgionne, G. A. (2004). A multiple-criteria framework for evaluation of decision support systems. *Omega*. 32 (4), 323–332. http://doi.org/10.1016/j.omega.2004.01.003

Pick, R., Weatherholt, N. (2012). A Review On Evaluation And Benefits Of Decision Support Systems. *Review of Business Information Systems*. 17 (1): 7–20.

Pilavachi, P., Stephanidis, S. (2009). Multi-criteria evaluation of hydrogen and natural gas fuelled power plant technologies. *Applied Thermal*. 29: 2228–2234.

Rahman, S. R. A., Ahmad, H., Mohammad, S., Rosley, M. S. F. (2015). Perception of Green Roof as a Tool for Urban Regeneration in a Commercial Environment: The

Secret Garden, Malaysia. *Procedia - Social and Behavioral Sciences*. 170: 128–136. http://doi.org/10.1016/j.sbspro.2015.01.022

Rahman, S. R. A., Ahmad, H., Rosley, M. S. F. (2013). Green Roof: Its Awareness Among Professionals and Potential in Malaysian Market. *Procedia - Social and Behavioral Sciences*. 85: 443–453. http://doi.org/10.1016/j.sbspro.2013.08.373

Ramík, J., Perzina, R. (2010). A method for solving fuzzy multicriteria decision problems with dependent criteria. *Fuzzy Optimization and Decision Making*. 9 (2): 123–141. http://doi.org/10.1007/s10700-010-9078-x

Refahi, A. H., Talkhabi, H. (2015). Investigating the effective factors on the reduction of energy consumption in residential buildings with green roofs. *Renewable Energy*. 80: 595–603. http://doi.org/10.1016/j.renene.2015.02.030

Rennie, J., Singh, N. (1995). A guide for field projects on adaptive strategies. International Institute for Sustainable Development, Ottawa.

Rhee, C., Rao, H. (2008). Evaluation of decision support systems. Handbook on Decision Support Systems 2. *International Handbooks Information System*.: 313-327.

Rogers, M., Lopez, E. (2002). Identifying critical cross-cultural school psychology competencies. *Journal of School Psychology*. 40 (2): 115-141.

Rowe, G., Wright, G. (1999). The Delphi technique as a forecasting tool: issues and analysis. *International Journal of Forecasting*. 15 (4): 353–375.

Saadatian, O., Sopian, K., Salleh, E., Lim, C. H., Riffat, S., Saadatian, E., Sulaiman, M. Y. (2013). A review of energy aspects of green roofs. *Renewable and Sustainable Energy Reviews.* 23: 155–168.

Saaty, T. (1996). Decision making with dependence and feedback: The analytic network process. *RWS Publication*.

Saaty, T. L., Analytic, T., Process, H., Saaty, T. L. (1980). The Analytic Hierarchy Process. *Education*. 1–11.

Saaty, T. L., Özdemir, M. S. (2015). How Many Judges Should There Be in a Group? *Annals of Data Science*. 1 (3): 359–368. http://doi.org/10.1007/s40745-014-00264

Safikhani, T., Abdullah, A. M., Ossen, D. R., Baharvand, M. (2014). A review of energy characteristic of vertical greenery systems. *Renewable and Sustainable Energy Reviews*. 40: 450–462. http://doi.org/10.1016/j.rser.2014.07.166

Sarfaraz, A., Mukerjee, P., Jenab, K. (2012). Using fuzzy analytical hierarchy process (AHP) to evaluate web development platform. *Management Science Letters*, 2 (1): 253–262.

Schrader, S., Böning, M. (2006). Soil formation on green roofs and its contribution to urban biodiversity with emphasis on Collembolans. *Pedobiologia*. 50 (4): 347–356. http://doi.org/10.1016/j.pedobi.2006.06.003

Seok, H., Kang, J., Sung, M. (2012). Acoustic effects of green roof systems on a low-pro fi led structure at street level. *Building and Environment*. 50: 44–55. http://doi.org/10.1016/j.buildenv.2011.10.004

Sheng, L. X., Mari, T. S., Ariffin, A. R. M., Hussein, H. (2011). Integrated Sustainable Roof Design. *Procedia Engineering*. 21: 846–852.

Silva, C. M., Gomes, M. G., Silva, M. (2016). Green Roofs Energy Performance in Mediterranean Climate. *Energy and Buildings*. 116: 318–325. http://doi.org/10.1016/j.enbuild.2016.01.012

Simon, H. (1977). The logic of heuristic decision making. Chapter- Models of Discovery. *Boston Studies in the Philosophy of Science*. 54:154–175.

Skulmoski, G., Hartman, F., Krahn, J. (2007). The Delphi method for graduate research. *Journal of Information Technology Education*. 6.

Słowiński, R. (1986). A multicriteria fuzzy linear programming method for water supply system development planning. *Fuzzy Sets and Systems*. 19 (3): 217–237. http://doi.org/10.1016/0165-0114(86)90052-7

Small, E. P., Mazrooei, M. Al. (2016). Alternative Approaches for Development of a Construction-specific Decision Support Tool for Sustainable Construction Operations. *Procedia Engineering*. 145: 1013–1020.

Stovin, V., Vesuviano, G., Kasmin, H. (2012). The hydrological performance of a green roof test bed under UK climatic conditions. *Journal of Hydrology*. 414–415: 148–161. http://doi.org/10.1016/j.jhydrol.2011.10.022

Susca, T., Gaffin, S. R., Dell'osso, G. R. (2011). Positive effects of vegetation: urban heat island and green roofs. *Environmental Pollution*. 159 (8): 2119–26. http://doi.org/10.1016/j.envpol.2011.03.007

Tan, C. L., Wong, N. H., Jusuf, S. K. (2014). Effects of vertical greenery on mean radiant temperature in the tropical urban environment. *Landscape and Urban Planning*. 127: 52–64. http://doi.org/10.1016/j.landurbplan.2014.04.005

Tan, W. (2008). Practical Research Methods (Third). Pearson Education.

Tavana, M., Zareinejad, M., Di Caprio, D., Kaviani, M. A. (2016). An integrated intuitionistic fuzzy AHP and SWOT method for outsourcing reverse logistics. *Applied Soft Computing Journal*. 40: 544–557.

Theodosiou, T. G. (2003). Summer period analysis of the performance of a planted roof as a passive cooling technique. *Energy and Buildings*. 35 (9): 909–917. http://doi.org/10.1016/S0378-7788(03)00023-9

Tilston, C. (2008). Rooftop and terrace gardens. Wiley; John Wiley [distributor].

Tonietto, J., Carbonneau, A. (2004). A multicriteria climatic classification system for grape-growing regions worldwide. *Agricultural and Forest Meteorology*. 124 (1): 81–97. http://doi.org/10.1016/j.agrformet.2003.06.001

Townshend, D. (2007). Study on Green Roof Application in Hong Kong. Hong Kong.

Tsang, S. W., Jim, C. Y. (2011). Theoretical evaluation of thermal and energy performance of tropical green roofs. *Energy*. 36 (5): 3590–3598. http://doi.org/10.1016/j.energy.2011.03.072

Turban, E., Aronson, J. (1998). *Decision Support Systems and Intelligent Systems*. Intelligent agents and creativity.

Turban, E., Sharda, R., Delen, D. (2007). Decision support and business intelligence systems. Pearson Edition, India.

Van Renterghem, T., Botteldooren, D. (2008). Numerical evaluation of sound propagating over green roofs. *Journal of Sound and Vibration*. 317 (3): 781–799. http://doi.org/10.1016/j.jsv.2008.03.025

Van Renterghem, T., Botteldooren, D. (2009). Reducing the acoustical façade load from road traffic with green roofs. Building and Environment, 44(5), 1081–1087. http://doi.org/10.1016/j.buildenv.2008.07.013

Van Renterghem, T., Botteldooren, D. (2014). Influence of rainfall on the noise shielding by a green roof. *Building and Environment*. 82: 1–8. http://doi.org/10.1016/j.buildenv.2014.07.025

Van Woert, N., Rowe, D. (2005). Green roof storm water retention. *Journal of environmental quality*. 34 (3): 1036-1044.

Veltri, A. (1985). Expected use of management principles for safety function management.

Vijayaraghavan, K. (2016). Green roofs: A critical review on the role of components, benefits, limitations and trends. *Renewable and Sustainable Energy Reviews*. 57: 740–752. http://doi.org/10.1016/j.rser.2015.12.119

Vincenzo Costanzo, Gianpiero Evola, Luigi Marletta. (2014). Energy savings in buildings or UHI mitigation? Comparison between green roofs and cool roofs. *Third International Conference on Countermeasures to Urban Heat Island*. 226–237. http://doi.org/10.1016/j.enbuild.2015.04.053

Wang, J. J., Jing, Y. Y., Zhang, C. F., Zhao, J. H. (2009). Review on multi-criteria decision analysis aid in sustainable energy decision-making. *Renewable and Sustainable Energy Reviews*. 13 (9): 2263–2278.

Wang, M., Lin, Y. (2008). To construct a monitoring mechanism of production loss by using Fuzzy Delphi method and fuzzy regression technique–A case study of IC package testing. *Expert Systems with Applications*. 35: 1156–1165.

Wang, Z.-H. (2014). Monte Carlo simulations of radiative heat exchange in a street canyon with trees. *Solar Energy*. 110: 704–713.

Wiecko, G. (2006). Fundamentals of tropical turf management.

William, R., Goodwell, A., Richardson, M., Le, P. V. V., Kumar, P., Stillwell, A. S. (2016). An environmental cost-benefit analysis of alternative green roofing strategies. *Ecological Engineering*. 95: 1–9.

Williams, N. S. G., Rayner, J. P., Raynor, K. J. (2010). Green roofs for a wide brown land: Opportunities and barriers for rooftop greening in Australia. *Urban Forestry Urban Greening*. 9 (3), 245–251. http://doi.org/10.1016/j.ufug.2010.01.005

Wong, G. K. L., Jim, C. Y. (2015). Identifying keystone meteorological factors of green-roof stormwater retention to inform design and planning. *Landscape and Urban Planning*. 143: 173–182.

Wong, N. H., Kwang Tan, A. Y., Tan, P. Y., Chiang, K., Wong, N. C. (2010). Acoustics evaluation of vertical greenery systems for building walls. *Building and Environment*. 45 (2): 411–420. http://doi.org/10.1016/j.buildenv.2009.06.017

Wong, N. H., Tay, S. F., Wong, R., Ong, C. L., Sia, A. (2003). Life cycle cost analysis of rooftop gardens in Singapore. *Building and Environment*. 38 (3): 499–509. http://doi.org/10.1016/S0360-1323(02)00131-2

Wong, Cheong, D. K., Yan, H., Soh, J., Ong, C., Sia, A. (2003). The effects of rooftop garden on energy consumption of a commercial building in Singapore. *Energy and Buildings*, 35 (4): 353–364. http://doi.org/10.1016/S0378-7788(02)00108-1

Wu, J. (2014). Urban ecology and sustainability: The state-of-the-science and future directions. *Landscape and Urban Planning*. 125: 209–221. http://doi.org/10.1016/j.landurbplan.2014.01.018

Yadollahi, M. (2013). Budget allocation management model for seismic rehabilitation of infrastructure assets. PhD Thesis. Universiti Teknologi Malaysia.

Yang, H. S., Kang, J., Choi, M. S. (2012). Acoustic effects of green roof systems on a low-profiled structure at street level. *Building and Environment*. 50: 44–55. http://doi.org/10.1016/j.buildenv.2011.10.004

Yang, J., Yu, Q., Gong, P. (2008). Quantifying air pollution removal by green roofs in Chicago. *Atmospheric Environment*. 42(31) :7266–7273.

Yih, C. Y. (2010). E-Dispute Resolution Model on Contractual Variations. PhD Thesis. Universiti Teknologi Malaysia.

Yusof, M., Johari, M. (2012). Identifying green spaces in Kuala Lumpur using higher resolution satellite imagery. *On Sustainable Tropical Design Research*. 5 (2): 93–106. Retrieved from http://psasir.upm.edu.my/32927/

Zahir, M. H. M., Raman, S. N., Mohamed, M. F., Jamiland, M., Nopiah, Z. M. (2014). The Perception of Malaysian Architects towards the Implementation of Green Roofs: A Review of Practices, Methodologies and Future Research. *E3S Web of* Conference. EDP Sciences. 3. 1022. http://doi.org/10.1051/e3sconf/20140301022

Zarandi, M., Razaee, Z., Karbasian, M. (2011). A fuzzy case based reasoning approach to value engineering. *Expert Systems with Applications*. 38 (8): 9334–9339.

Zavadskas, E., Turskis, Z., Kildienė, S. (2014). State of art surveys of overviews on MCDM/MADM methods. Technological and Economic *Development of Economy*. 20 (1): 165–179.

Zhang, J. P., Hu, Z. Z. (2011). BIM- and 4D-based integrated solution of analysis and management for conflicts and structural safety problems during construction: 1. Principles and methodologies. *Automation in Construction*. 20 (2): 155–166. http://doi.org/10.1016/j.autcon.2010.09.013

Zhang, Q., Miao, L., Wang, X., Liu, D., Zhu, L., Zhou, B., Liu, J. (2015). The capacity of greening roof to reduce stormwater runoff and pollution. *Landscape and Urban Planning*. 144: 142–150. http://doi.org/10.1016/j.landurbplan.2015.08.017

Zhang, X., Shen, L., Tam, V. W. Y., Lee, W. W. Y. (2012). Barriers to implement extensive green roof systems: A Hong Kong study. *Renewable and Sustainable Energy Reviews*. 16 (1): 314–319. http://doi.org/10.1016/j.rser.2011.07.157

Zhu, K., Jing, Y., Chang, D. (1999). A discussion on extent analysis method and applications of fuzzy AHP. European Journal of Operational Research, 116 (2): 450–456.