THE REPUBLIC OF TURKEY
BAHCESEHIR UNIVERSITY

THE CHALLENGES AND OPPORTUNITIES OF LIVING WALL SYSTEMS INTEGRATION INTO BUILDING'S FACADES IN AMMAN

Master's Thesis

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This is to certify that we have read this thesis and we find it fully adequate in scope, quality and content, as a thesis for the degree of Master of Science.

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ABSTRACT

THE CHALLENGES AND OPPORTUNITIES OF LIVING WALL SYSTEMS INTEGRATION INTO BUILDING'S FACADES IN AMMAN

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Green areas are declining within cities due to the rapid urban expansion which has caused many environmental problems. Therefore, architects are calling to bring nature back to cities through the integration of "Living Wall System" into building's skins, due to its many advantages. It has the ability to mitigate the negative impacts resulted from urban expansion, such as: decreasing the urban temperature, reducing energy consumption and absorbing toxic gases from the air. Therefore, living walls became popular and spotlighted in many cities around the world. However, in some cities like Amman, this technology is not widely acknowledged and applied.

The aim of this research is to clarify the challenges and opportunities of living wall system integration into building's facades in the city of Amman. In this study, a qualitative research methodology was applied to achieve a deep understanding of the research area. In-depth interviews for data gathering were made with different specialists within Amman and abroad.

The findings of this research exposed that the living wall system faces some main challenges such as; lack of knowledge, lack of encouragement, expensive costs and maintenance issues. However, the findings also presented some potentials of living walls that can help to pave its way and overcome its challenges in Amman, such as raising awareness, governmental support, investment benefits and water efficiency.

Keywords: Living Wall System, Vertical Garden, Green Facade, Green Architecture.

ÖZET

AMMAN'DA BİNA CEPHELERİNE YAŞAYAN DUVAR SİSTEMLERİ ENTEGRASYONUNUN ZORLUKLARI VE FIRSATLARI

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Hızlı kentsel genişleme nedeniyle şehirlerde yeşil alanlar azalmakta, bu da birçok çevre sorununa neden olmaktadır. Bu nedenle mimarlar, birçok avantajı olan "Yaşayan Duvar Sistemleri"nin bina cephesine entegrasyonu ile doğayı şehirlere geri getirmeye çalışıyorlar. Bu sistemler, şehir sıcaklığını düşürmek, enerji tüketimini azaltmak ve havadan zararlı gazları emmek gibi, kentsel genişlemeden kaynaklanan olumsuz etkileri hafifletme özelliğine sahiptir. Bu nedenle, canlı duvarlar dünya çapında birçok şehirde popüler hale geldi ve göze çarpıyordu. Ancak, Amman gibi bazı şehirlerde, bu teknoloji yaygın olarak kabul görmemekte ve uygulanmamaktadır.

Bu araştırmanın amacı, Amman kentindeki binanın cephelerine yaşayan duvar sistemi entegrasyonunun zorluklarını ve fırsatlarını netleştirmektir. Bu çalışmada, araştırma alanını derinlemesine anlamak için nitel bir araştırma yöntemi kullanılmıştır. Amman ve yurtdışındaki farklı uzmanlar ile derinlemesine görüşmeler yapılmıştır.

Bu araştırma, yaşayan duvar sistemlerinin uygulanmasındaki ana zorlukların, bilgi eksikliği, teşvik eksikliği, pahalı maliyet ve bakım sorunları olduğunu ortaya çıkartmıştır. Bununla birlikte, araştırma bulguları, farkındalık yaratma, devlet desteği, yatırım avantajları ve su verimliliği gibi Amman'daki zorlukların üstesinden gelmeye yardımcı olabilecek bazı fırsatlar da sundu.

Anahtar Kelimeler: Yaşayan Duvar Sistemi, Dikey Bahçe, Yeşil Cephe, Yeşil Mimari.

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ABBREVIATIONS

GAM : Greater Amman municipality

JGBC : Jordan green building council

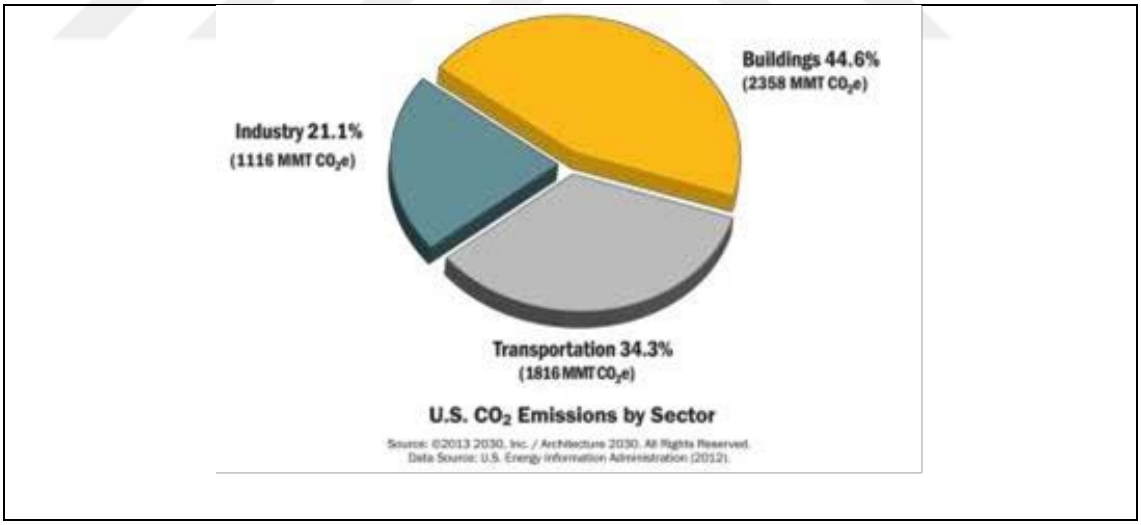
LWS : Living wall system

1. INTRODUCTION

1.1 RESEARCH BACKGROUND

According to The United Nations, more than half of the world's population live in cities and this percentage is expected to rise due to the continuous migration from rural areas to urban places. Moreover, it estimates that by 2050 the world urban population will increase to reach 82percent rising from 3.4 billion to 6.3 billion. The rapid increasing in population leads to huge demand for housing units and more expansion of urban areas and cities which means more occupation of the natural land by concrete buildings (Wond and Tan, 2009). According to Architecture 2030, buildings is it the main source of CO2 emission among industry and transportation sectors, buildings contribute half of the world's CO2 emissions.

Figure 1.1: Energy consumption by sector



Source: architecture 2030, n.d.

This occupation of the natural land has created unfair relation between nature and the built environment resulting in many environmental issues such as climate change, urban heat island, air and water pollution and depletion of resources. in order to fix this unfair relation, a new idea has been presented by architects and landscape designers calling to "bring the nature back to the city " aiming to have a healthy and balanced relation between

nature and the urban areas to help the environment and create a new sustainable way for the city urban lifestyle. The core of this transformation is Greenery systems which integrate plants and vegetation into building's envelope, since building skins (walls, roofs) provide a great amount of surface that facilitate the integration of these systems into the building envelopes (Wond and Tan, 2009).

Green roof and green wall systems are the main components of the greenery systems. Ecological, social and aesthetic impacts can be gained out of these environmental approaches, beside the environmental benefits like reduce the heat island effect in urban areas, improve the air quality and energy savings. (Perini et al ., 2011).

Green wall systems seem to be a promising methodology to naturalize our cities due to the large spread of tall and high-rise buildings in today cities, resulting in plenty of vertical spaces that can be invaded by vegetation vertical system. In addition, green wall system can be classified into two types , traditional and modern green walls.

Green façade is the traditional type of green walls, it based on climbing plants that is attached to the building directly or can be supported by trellis and cables . historically , green façade has been used since 2000 years, it derives from Babylon civilization which was a part of the famous Babylon hanging garden (Perini et al ., 2011) .

The second type of green walls is the living wall systems which is more complicated than the green façade because it requires a nutrients and irrigation system and consist of supporting structure which has to be attached to the wall , as well as , artificial growing mediums such as foam and mineral wool which carry the plants of this system and it can be replaced easily. Moreover , living wall systems have advantages such as the capability to be constructed indoor and outdoor and it works as cooling mechanism for the building inner spaces in summer and in winter work as insulation layer which keep the warm inside the building that leads to reduce the energy consumption in cooling and warming the temperature of building's inner space, as well as, mitigating urban heat island effect, clensing the air, absorbing CO2 and providing oxygen and works as a sound insulation. (Mir , 2011).

Amman as a case study

Amman is the capital city of the Hashemite kingdom of Jordan, that is located in north-west center of the country and it is the economic, political and cultural center of Jordan. Climatically, Amman has a hot and dry summer and the winter is cold and wet, as table (1:1) shows, the average maximum temperature in summer is 32℃ with low humidity. Furthermore, the summer period extends from May to late September where it is known as a rainless period. The winter period starts from November till April, sometimes in winter the temperature drops to zero or below during night-time but the average temperature is ranging from 12℃ and 21℃. The highest amounts of rainfalls occur in January and February but the annual amount of rainfall is at 480 mm (Potter et al, 2009).

Table 1.1: Amman annual climate

Month	Average minimum daily temperature (°C)	Average maximum daily temperature (°C)	Relative humidity (am)	Relative humidity (pm)	Average precipitation (mm)	Average wet days (+0.25 mm)
January	4	12	80	56	69	8
February	4	13	78	52	74	8
March	6	16	57	44	31	4
April	9	23	53	34	15	3
May	14	28	39	28	5	0.8
June	16	31	40	28	0	0
July	18	32	41	30	0	0
August	18	32	45	30	0	0
September	17	31	53	31	0	0
October	14	27	53	31	5	1
November	10	21	66	40	33	4
December	6	15	77	53	46	5

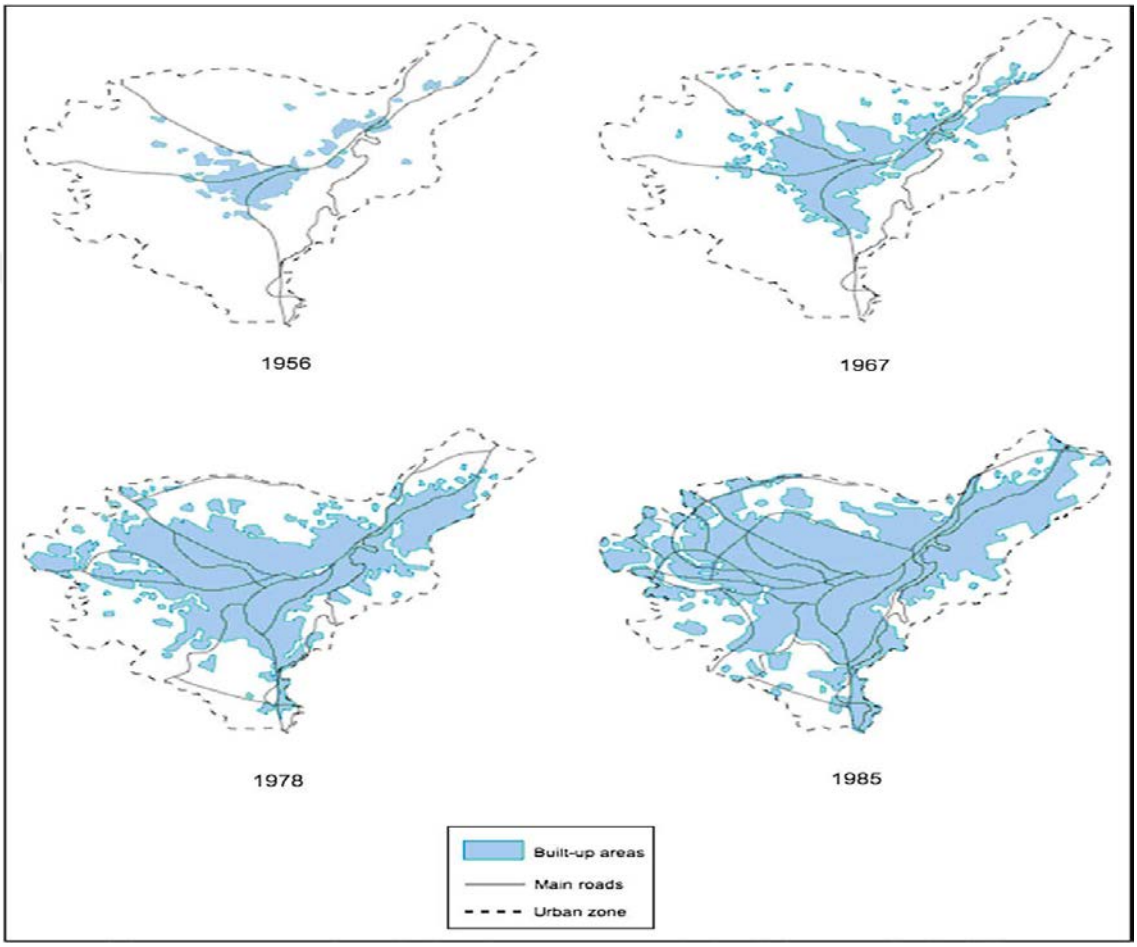
Source: (Potter et al, 2009).

Water scarcity is a real issue facing the city and the country, where it is considered as the third driest country in the world, Jordan depends only on one source of water which is rainfall, where this source won't be enough in the near future due to a rapid growth of population (Abu Hammad,2017 and Montgomery,2015).

Another critical issue facing Amman is the uncontrolled urban expansion of the city due to the dramatical growth in population, which turned it from a small village with 3000 inhabitants in the beginning of the 20th century to a large city that nowadays hosts over 4 million people and that is 40percent of the total population of Jordan. Two main factors behind this rapid growth in population, the migration of people from rural areas and neighboring cities, as well as, the migration of refugees from neighboring countries such as Palestine, Iraq and Syria due to wars and conflicts. The figure (1.1) shows how rapid

is the urban expansion within the city Amman, which has many negative impacts on the environment such as declining the green areas, air and sound pollution and increased the urban temperature (Potter et al, 2009).

Figure 1.2: Amman urban expansion



Source: (Potter et al, 2009)

According to the United nations, 2001 it is a responsibility for developing cities such as Amman to set polices and solutions to deal with negative impacts of urban expansion. LWS is one of the methods that has the ability to deal with environmental issues resulted from urban expansion due to its many environmental advantages (Urrestarazu, 2016). But according to the author's researches and observations few studies have been conducted about LWS in Amman, so the aim of this study is to investigate the challenges and opportunities of living wall systems in Amman.

1.2 RESEARCH AIM

The aim of this research is to investigate the challenges and opportunities of living wall systems in Amman, therefore, paving the way for their implementation and raising awareness about these systems.

1.3 RESEARCH QUESTION

The researcher has shaped the following queries to be the main research question:

What are the obstacles and the possibilities of the architectural integration of Living Wall Systems into building's facades in Amman?

The following are sub-queries that will help to answer the above question in the structure of the thesis:

What are the advantages and disadvantages of living wall systems?
What are the overall environmental impacts of LWS on humans, buildings and nature?
What are the main challenges that faces these systems as external cladding techniques?
Would water scarcity in Amman be a real obstacle for the implantation of LWS in the city?
Is the climate in Amman suitable for applying the system?
Would people in Amman accept the idea of covering their building's facades with vegetation?
To what extent LWS can be utilized in the Jordanian construction industry in Amman?

2 . LITERATURE REVIEW

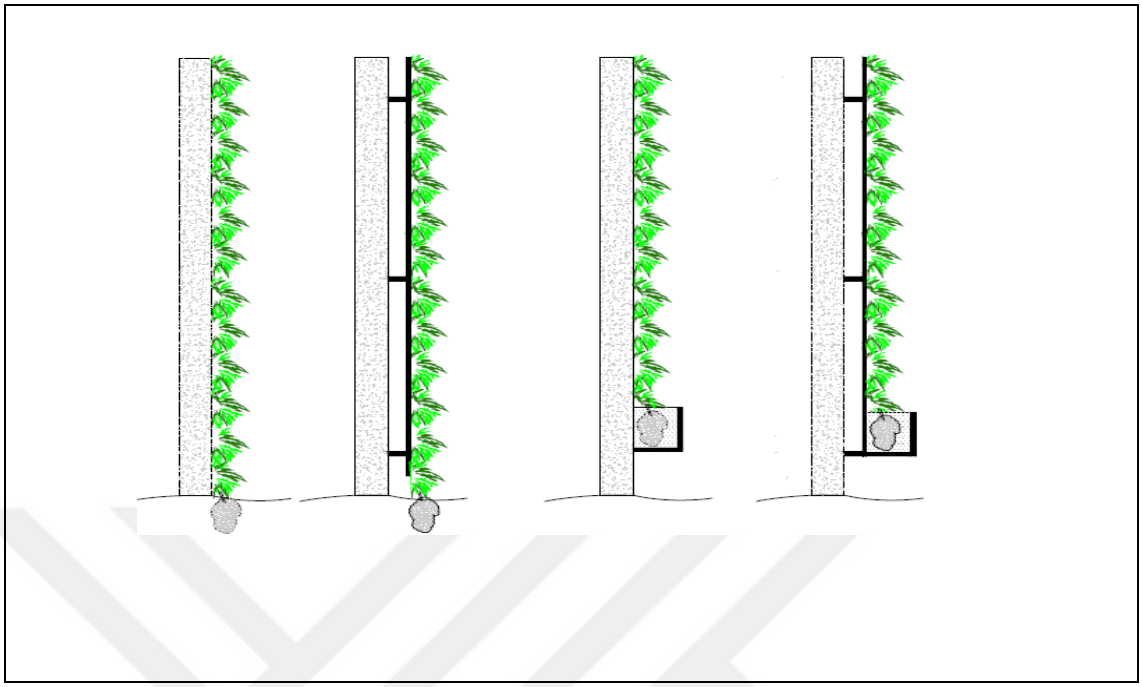
2.1 VERTICAL GREENERY

Vertical green, vertical garden, green façade, green wall and living wall are all a descriptive terms that are used to describe the process of integrating vegetation within any vertical surface such as: building's walls, facades, partition walls, etc. They are able to cover these surfaces completely or partially with plants (Ottele, 2011). The vertical greenery consists of many systems that have the same purpose but vary in components and in the way they are constructed, and these systems are divided under two categories regarding their methods of implementation, the green facades and living wall systems (Perini and Ottele, 2014).

Green façade is the traditional way of covering building's vertical surfaces with vegetation by the use of self-climbing plants that are directly attached to these surfaces or indirectly by the support of cables and trellis (Perini and Rosasco, 2013). As figure (2.1) shows, that these climbers are either planted at the base of the wall or rooted in planter boxes located at the ground level or it can be elevated to higher levels (Ottele, 2011). The climbing feature of these plants is the common factor between all the systems of green façade but when applying this method, it is important to consider the growth habit of some of these climbing plants that they need years to complete their full growth, some of these plants have a limited height to reach (Dunnett and Kingsbury, 2008).

Living wall system (LWS) is the advanced method of greening building's facades which is the core of this master thesis.

Figure 2.1: Different application types of green facade



Source: (Ottele, 2011)

2.2 LIVING WALL SYSTEM DEFINITION AND CLASSIFICATIONS

Living wall system is the modern method of vertical greenery systems that cover vertical surfaces of buildings with vegetation.

It is distinct from the traditional method in that LWS are able to host a wide variety of plant species and cover all kind of vertical surfaces indoor and outdoor regardless the size and the height of these surfaces, and that what makes it suitable for high buildings (Manso and Castro-Gomes, 2018), as well as, LWS can be applied in various climate conditions such as full sun, shade and they can adapt to both tropical and temperate climates (Mir, 2011).

The plants of the system are rooted in modular or panels such as planter boxes, revegetated panels and planted blankets that are fixed to a supporting structure which is attached vertically to the wall, these panels and models contain soil or artificial growing

mediums such as felt, foam and mineral wool. Furthermore, LWS is based on a hydroponic culture that provide a balance nutrients solution and contribute water and food to all the plants within the system (Wagemans, 2016).

The system usually employs evergreen small shrubs that don't require so much time to grow, it usually need one year or less for growth. On another hand, LWS requires intensive maintenance since the system carries a wide range of plants that need more attention (Perini and Ottele, 2014).

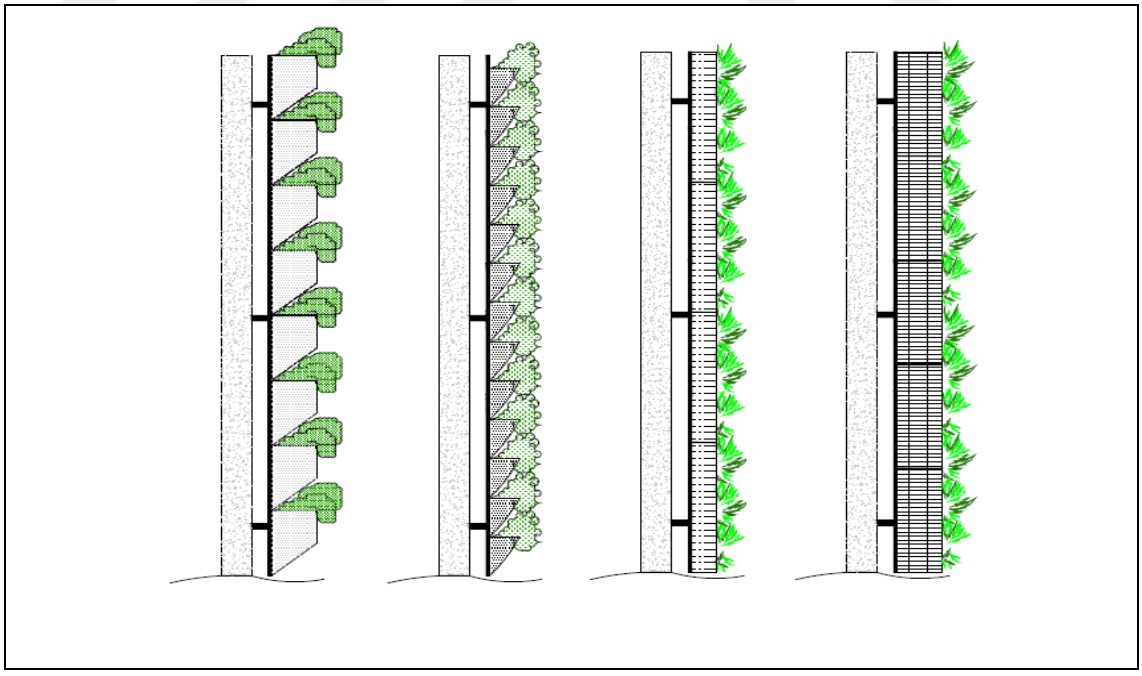
According to MIR, (2011) LWS consists of different types of systems that have been developed in the last decades, they are classified into three types of systems that vary in their characteristics and components as shown in figure (2.2), and they are:

A- LWS based on planter boxes

B- LWS based on felt layer

C- LWS based on prefabricated panels (1- mineral wool or 2- foam)

Figure 2.2: Types of living wall system (LWS)



From the left A- Planter boxes, B- Felt layers, C.1- Mineral wool panel, C.2- Foam panel

Source: (Mir, 2011)

LWS based on planter boxes

This is system is consisting of planter boxes filled with soil which carry the plants, and this is the only type of LWS that contain soil as growing medium, the boxes are made of plastic and they are hooked over each other on a supporting structure that is attached to the wall. The irrigation pipes are located above each box which provide sufficient water for each species (Mir, 2011).

LWS based on felt layers

This type of LWS is pioneered by the famous French botanist “Patrick Blanc”, the system is based on a double-felt layer made of non-woven polyamide felt that is stapled securely to the PVC panel which is carried by supporting frame attached to the wall, the outer felt layer is cut to from the pockets that hold various number of plants (Weinmaster, 2009)

LWS based on prefabricated panels (1-foam or 2-mineral wool)

This type of living walls is based on panels made of mineral wool or foam as well as different types of artificial substrates, but foam and mineral wool are the most common used substrates and they are a water efficient and suitable for a wide range of plants and climate types. The plants of such a system are planted into the substrate before installing them into the wall and this is why it is considered as prefabricated living wall system. Each square meter of these panels is capable to hold between 23-25 plants. The irrigation pipes are placed at top of the panel where they provide water and nutrients downward to system by the help of gravity (Wagemans, 2016).

2.3 LIVING WALL COMPONENTS

Each type of LWS consist of four main components (supporting elements, growing media, irrigation system and vegetation). These elements came into different forms, materials and applications among the three types of LWS (Tzortzi and Sophocleous, 2018). A detailed description of these components is introduced in this section.

2.3.1 Supporting elements

In order to understand the structural compositions of living wall systems clearly, it is important to distinguish between their two supporting elements,

The first one is the main supporting structure which is a steel frame that carry and support all the components of the system, and it is attached to wall or vertical surface with a mechanical fixation method. Furthermore, an air cavity is created between the wall and the system which protect the wall from humidity and moisture. The frame structure is a common element between all the different three types of LWS (Manso and Castro-Gomes, 2018).

The second supporting element is the substrate holder, this supporting element holds the substrates or the growing mediums which support the plants, moreover, each system of living wall has it is own substrate holder structure that vary in application methods, characteristics and materials (Jaafar et al, 2011).

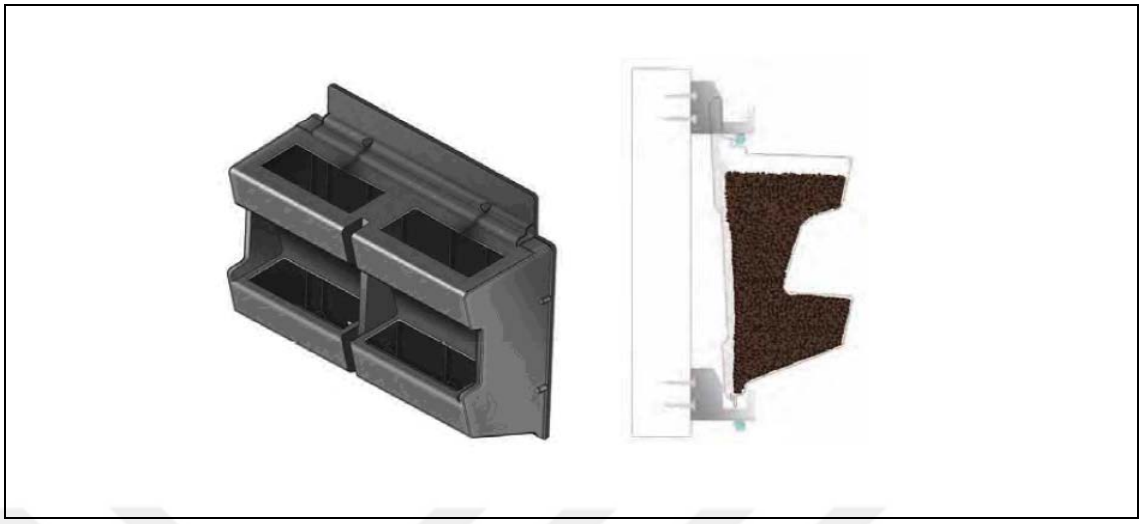
LWS based on felt layer: consists of three main supporting parts, the metal frame that is attached to the wall, and PVC panel which is fixed to the metal frame, this panel provide a rigidity to the whole system, and then the substrate holder which is made of two layer of recycled synthetic fibers and they are stapled to the PVC panel. These layers are highly absorbent carpet and they provide a mechanical support to the plants when a cut is made on the outer layer which from the pockets where they allow the plants to be inserted in between (Petty, 2008).

Figure 2.3: LWS based on felt layers

Source: **(**Mir, 2011)

The substrate holder of LWS based on planter boxes is made of indestructible plastic boxes that hold the substrates and the plants, these boxes are available in the market as individual boxes or as models contain many boxes together, also, they have a specific dimension that depends on the supplier standards which vary from different manufactural sources. These boxes or models are attached to main supporting frame profiles by mounting brackets or hooks which are located at the back surface of the boxes (Mir, 2011).

Figure 2.4: Planter boxes



Source: **(**Mir, 2011)

LWS based on prefabricated panels consists of modular panels that hold different types of substrate which support the plants, these panels are made of different materials such as plastic and metal sheets and they are available in different specific dimensions and styles (Dunnet and Kingsbury, 2008). The plants in this system are rooted into the substrate before hanging them vertically and that is why it is considered as a prefabricated panels (Wagemans, 2016). After inserting the plants, as the previous method, the panels are attached to the main metal frame profiles by mounting brackets and hooks which are located at the back side of the panels. In order to ensure the continuity of the system, interlocking parts are included on the sides of each panel to connect all the panels in the system with each other (Manso and Gomes, 2014). Some specific types of substrate may require a steel grid on the front side to prevent plants and substrate to fall (Koumouds, 2011).

2.3.2 Growing media

The growing media is a very essential component of LWS, because it is the place where the plants are rooted and get their needs of water and nutrients that are required for their survival. Many artificial growing mediums have been developed and each system of living walls use different types of these mediums (Hopkins and Goodwin, 2011).

LWS based on felt layer don’t contain a substrate or soil, whereas the two absorbent screens that hold the plants work as both a supporting element and growing media for the

plants, moreover, due to the lake of substrate, the system require a permeant supply of water where these screens need to be constantly wet and that is possible by the use of hydroponic system which facilitate the process of provide a constant water and nutrients needed for the plants (Hedberg, 2008).

LWS based on planter boxes use natural soil or potting soil as growing media for the plants, and it is the only system that contain soil, because of the characteristic and set of these boxes that can hold the soil and prevent its falling (Mir, 2011).

LWS based on prefabricated panels employ different types of substrates that is made out of organic and inorganic materials but usually foam and mineral wool are the most common types, because they are a very water efficient, stable and lightweight where they reduce the weight of the system and also can adapt different weather conditions (Bindschedler and Lassalle, 2010).

2.3.3 Irrigation system

All living wall systems require a safe and secure irrigation system that provides water to the plants, this irrigated water contains nutrients, fertilizers and different types of minerals which help to improve the plants sustainability and growth (Manso and Gomes, 2014). LWS is based on hydroponic watering principles, therefore, consumes half amount of water required for the conventional irrigation methods and that's what makes it an efficient water option.

The irrigation system that is used in LWS is an automated system which consists of electrical and mechanical equipment, thereby, require a power source to operate it, as well as, a secure space that is remoted from the wall. Water sensors can be added in the growing media, in order to monitor the plants needs of water and nutrients, therefore, turning on or off the system when required (Hopkins and Goodwin, 2011).

The process of supplying water is made by installing an irrigation pipes at the top of the system, but each system has different applications and methods. The irrigation pipes in LWS based on felt layers is placed at the top of the system in between the two absorbent layers where these preamble screens allow the uniform suppling of water to the whole system by gravity (Manso and Gomes, 2014).

In case of LWS based on planter boxes, the irrigation pipes run along the boxes where a drip is located above each box providing all the boxes sufficient water and nutrients (Mir, 2011).

LWS based on prefabricated panels contain a recess at the top of each panel that hold the irrigation pipes where water and nutrients is delivered to the whole panel by the use of gravity.

Finally, in order to control the water losses, all the types of LWS have a gutter at the base of the system that store excess water and recycle it back to the system (Manso and Gomes, 2014).

2.3.4 Vegetation

The core characteristic of LWS is the ability to host a wide variety of different types of plant species that allow the creation of art works based on applying different patterns, colours and shapes to the building's facades. However, the plant selection should not be aesthetic consideration but rather on the climatic factors to ensure the plants longevity. Wide range of ferns, shrubs, succulents and herbaceous are suitable for LWS (Urrestarazu et al, 2016).

2.4 CHARACTERISTICS OF LIVING WALL SYSTEMS

2.4.1 Life-time cycle

The service life of LWS is varying among the different types these systems. Moreover, it is important to notice that each of the four main components of LWS within each type has different life expectancy. However, LWS based on planter boxes has the longest service life compared with LWS based on felt layer and prefabricated panels who both share the same life expectancy.

The structural elements in all three types of LWS have the same service life which is 50 years, the irrigation system that is used in these systems need to be replaced every 7.5 years due to salts crystallizing issue. Furthermore, the service life of growing media in LWS based planter boxes is assumed to be 50 years. While it is 10 years in both the felt

layers and prefabricated panels. In addition, the plants life expectation in planter boxes is 10 years and it is 3.5 years for both felt layers and prefabricated. Therefore, the yearly plants replacement percentage is 10percent of the total plants in planter boxes and 30percent for other types (Ottele, 2011; Mir, 2011).

2.4.2 Cost

The initial cost to install LWS is varying among the three different types of these systems, the cost range lay between 350-1200 euro per square meter. LWS based on prefabricated panels is the most expensive system, while the cheapest is the felt layers. The following is a rang of costs for the installation of LWS in many European markets:

a. LWS based on planter boxes: 400-600 Euro/m^2
b. LWS based on felt layers: 350-750 Euro/m^2
c. LWS based on prefabricated panels: 750-1200 Euro/m^2 (Perini and Ottele, 2014).

2.4.3 Weight

The weight of LWS includes all the components of the system except the plants weight, each type of these systems differs in its own weight. The following is an estimated weight per square meter for each type:

a. LWS based on planter boxes: over 150 Kg/m^2.
b. LWS based on felt layers: 100 kg/m^2.
c. LWS based on prefabricated panels (foam): 100-120 kg/m^2.
d. LWS based on prefabricated panels (mineral wool): 40-60 kg/m^2 (Mir, 2011).

2.4.4 Water use

The amount of water that each type of LWS requires is approximately the same, where in summer the system requires between 2-5 L/m^2 per day while in winter it requires only 1 L/m^2 per day. However, these figures would differ depending on the climatic conditions (Hopkins and Goodwin, 2011).

2.4.5 Maintenance

Maintenance is an essential for the life of living wall system, since it is a living system that requires a constant maintenance. Mainly, maintenance is needed for vegetation rather than the construction itself where they need to trim twice a year due to the radical growth habit of some plants which may cause a serious problem if left without pruning. Also, the system needs replanting the dried-out plants by new one. In addition, irrigation system which provides water, nutrients and fertilizers is essential to ensure the continuity of LWS and that requires a serious maintenance specially in winter to prevent any frosting damages (Mir, 2011).

2.5 DESIGN PRINCIPLES

There are many principles or influences that affect the designing process of LWS, all of these influences are linked to the climate, so in order to design a successful LWS, these climatic influences need to be taken into consideration such as temperature and humidity, wind and orientation (Hopkins and Goodwin, 2011).

2.5.1 Temperature and humidity

Before designing LWS in any region, it is important to study the local climate and its characteristics deeply, in order to make the right selection of plants that can adapt to specific climate conditions and their amount of water required. The temperature and humidity play an important role in plants life and their need of water, when the temperature increases the plants require more water and some plants cannot adapt hot and humid weather condition and vice versa, so it is important to be aware of these conditions. On the other hand, ignoring these influences may leads to failure of the system because of the wrong selection of plants regarding their adaptation to specific temperature and humidity (Hopkins et al, 2010).

2.5.2 Wind

It is essential to investigate the wind flow around the selected location, building and within the city. In order to avoid a critical issue. For instance, when a wind hits a building,

it diverts to all directions around all the sides of it and that compresses the air molecules, therefore, increases the wind velocity which has an impact on LWS supporting elements and the plants themselves. The increase of wind speed creates a pressure on LWS components, if not supported well, they may fail to resist the pressure which may cause damages or may destroy the whole system. So, it is important to study the wind circulation and speed in order to avoid these problems, especially when designing for high buildings where the wind velocity is very high in higher floors (Hopkins and Goodwin, 2011).

2.5.3 Orientation

The orientation plays an important role in the performance of LWS, so the location and the direction of LWS should be taken into consideration, because each direction differs with regards to the sun light exposure. For instance, the north façade of a building gets indirect sunlight during the day, whereas the south façade is exposed to full sunlight along the day, so it is important to understand the relation between the sunlight direction and the orientation of each façade, in order to select plants that are suitable for each case. Whereas, some plants prefer indirect sunlight and cannot adapt the full exposure of sunlight and that also affects the amount of water required (Hopkins and Goodwin, 2011).

2.6 ADVANTAGES AND DISADVANTAGES OF LWS

2.6.1 Advantages of LWS

Health and wellness

According to a study carried out at Washington state university, employees who are surrounded by plants are more productive and less stressed than those who work in absence of plants, because plants help people to feel relax and focused. Therefore, they cause an increase in creativity, productivity and problem-solving capabilities of the employees. (Lohr et al, 1996). Another study was carried out at the Norwegian Agricultural University, which confirms the ability of plants in work places to decrease symptoms such as cough, fatigue and dry/itchy skin, therefore, making people healthier and decreasing the number of days off due to “sickness” (Bringslimark et al, 2006). According to Ulrich,2002, hospitals with gardens have been shown to be a positive

influence on patient's well-being and clinical improvement outcomes, such as shorten their stays and reduce pain medication intake.

Building protection

Building protection is another advantage of the many LWS have, where they protect the building envelops from cracks, fractures and general deterioration that occur due to a constant change in temperature which leads to the contraction and expansion of the building's materials. Therefore, LWS reduce the flux in temperature and that prevents these harmful events to occur (Weinmaster, 2009). According to Hedberg, 2008, LWS increase the longevity and integrity of building's exterior facades by protecting them from high speed wind, precipitation, UV radiation and corrosive acid rain.

Increase property value

LWS adds value to the property, through increasing the attractiveness of buildings which help to create a land mark building that is more noticeable in the city. Therefore, increases sales prices of the property and achieve higher rental (Hopkins et al, 2010).

Improving air quality

It is scientifically proven that LWS is efficient in improving air quality, indoor and outdoor, and minimizing air pollution effect that urban areas face, that resulted from the vehicles and factories exhaust, and that can be achieved through the ability of plants to act as an air filter that absorb the polluted air particles and gaseous pollutants such as CO_2 and NO_x and release oxygen (Fell, 2011).

Reduce energy consumption

Many studies have demonstrated the important role of LWS in reducing energy consumption for cooling and heating of buildings (Feng and Hewage, 2013). In warm climates, building's walls become hot and causes the temperature to increase inside buildings, leading to more energy consumption for cooling systems. Therefore, covering the building's facades with vegetation can lower the wall surface temperature and building cooling load which results in saving energy used for air-conditioning (Timur and Karaca, 2013). Furthermore, According to Ottelé et al., 2011, plants ensure the cooling

effect of LWS in warmer climates when they reflect and absorb most of falling sunlight due to their biological functions such as photosynthesis and evaporation, so, only 5percent-30percent passes through building's walls. In winter, LWS reduce the energy consumption for heating due to the air layer created between the LWS and the façade which makes the system act as an extra insulation layer which prevent transmission of heat from inside to outside and that keeps the building warm, so, less energy is used for warming (Feng and Hewage, 2013).

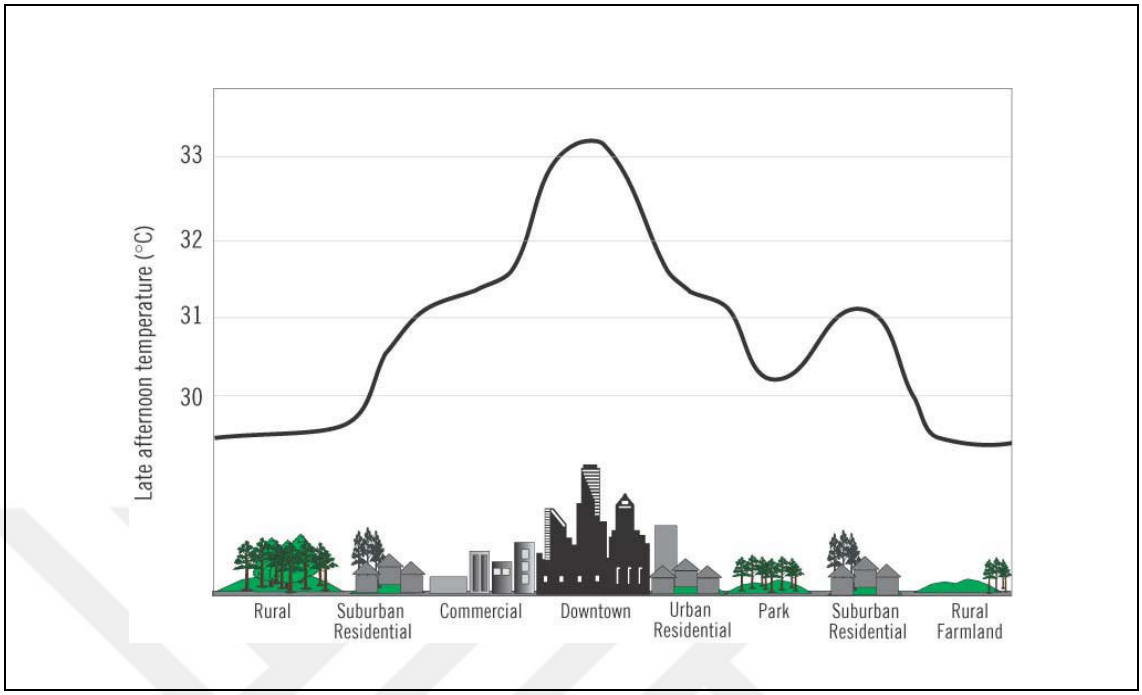
Sound insulation

Sound in urban areas is considered a serious issue due to the sound pollution resulting from vehicles movement and human activities that occur every day close to our living and working spaces (Wong et al,.2010). LWS are able to address this issue as plants abilities to absorb, reflect and diffract sound waves (Wagemans, 2016), In addition, soil, substrate and other materials used in LWS, all together insulate against noise. LWS works as sound insulation layer that protect our places from sound pollution where it can reduce noise and sound vibration up to 40dB inside our buildings (Timur and Karaca, 2013).

Mitigating urban heat island

j After the industrial revaluation, urban areas have been dramatically expanded, a large number of natural lands has been occupied by urban materials, Therefore, minimized the vegetation within cities, this lack of vegetation is one of the main reasons for rising in urban temperature (Alexandri and Jones, 2006). The rising in urban temperature comparing with the lower temperature of rural areas is scientifically known as Urban Heat Island Effect, where it formed due to the replacement of the natural land cover by buildings, paving and infrastructure, leads to minimizing the effects of evapotranspiration and shading that provide a cooling effect in nature. In addition, the surfaces of buildings and other urban structures have an absorption property where they absorb heat and store it, then retain it back at the evening and that causes a rising in the temperature as well as other negative effects (Dunnett and Kingsbury 2008).

Figure 2.5: Urban heat island diagram



Source: **(Alexandri and Jones, 2006)**

Bringing vegetation back to city through the implementation of LWS, can deal with issue of UHIE, because of the abilities of plants to utilize heat and transfer it to energy which power the evapotranspiration process that plants need, Thereby, providing a cooling effect within urban areas. Moreover, when integrating LWS into building's facades, they cover the absorbed surfaces and prevent them from storing heat and that moderate the temperature of the urban environment, So, LWS is considered as an effective method for mitigating urban heat island effect (Petty, 2003).

2.6.2 Disadvantages of LWS

Maintenance

Maintenance is an essential for the life of living wall system, since it is a living system that requires a constant maintenance, therefore, if the maintenance is absent for whatever reason, that leads to negative effects. Mainly, maintenance is needed for vegetation rather than the construction itself. They need trim twice a year due to the radical growth habit of some plants which may cause a serious problem if left without pruning. Also, the system needs to replanting the dried-out plants by new one. In addition, irrigation system

which provide water, nutrients and fertilizers is essential to ensure the continuity of LWS and that require a serious maintenance specially in winter to prevent any frosting damages (Mir, 2011).

Lack of knowledge

Unfortunately, the majority of people lack the knowledge of Living Wall System, where its technology, products and functions are not widely acknowledged. Also, there are limited research and studies done about LWS. Therefore, this limits and challenges the possibilities of LWS to be implemented and constructed to different conditions (Tzortzi and Sophocleous, 2018).

Cost

Cost of LWS seems to be an obstacle for construction the system, the high prices of LWS makes it a very expensive cladding technique (Wagemans, 2016). According to Perini et al, 2010 the initial cost of LWS is between 350-1200 euro per square meter due to the variety of components involve in its composition such as an irrigation system, more plants species, and supporting structure. Besides that, the cost of maintenance is making the system costlier due the many maintenance activities the system requires.

Allergy issues

When implementing living wall in inner spaces, allergic reaction may occur to the users of these space, due to their allergy to some specific plants and their pollen. In order to avoid such an issue, a carful plants selection must be done to avoid plants that produce a large quantity of pollen which causes allergy (Tzortzi and Sophocleous, 2018).

3 . METHODOLOGY

3.1 RESEARCH METHOD

Since the aim of this dissertation is to understand, explain and investigate the factors behind the challenges that face living wall systems, a qualitative research method was applied. Whereas the purpose of such a method is to provide complete details and descriptions of a research area, without limiting the research scope and the nature of the ideas and responses of the participants (Collis and Hussey, 2003). Moreover, the main characteristic of qualitative research is that it provides holistic exploration and emphasize a complex situations and environments of a specific research subject and identify the different factors that are involved, Additionally, qualitative research is defined by non-numerical evidence, so the outcomes of the research are not measurable and quantifiable (Groat and Wang, 2013).

3.2 DATA COLLECTION METHOD

In order to achieve in-depth outputs and understanding of the research, a semi-structured interview was applied for the data gathering. According to Gill et al., 2014, interviews in general is a method for explore and identify participant's views, experiences and beliefs on specific themes, and also present a deeper knowledge and understanding of phenomena where little is already acknowledged about it. The main advantage of interviews is that they provide researchers a direct and personal contact with interviewees, Therefore, a better understanding of the matter (Langkos, 2014). Semi-structured interviews are the most flexible way among other types of interviews, they involve a several key questions whose help to define the research areas that should be explored, but at the same time, it allows interviewees to add divergent interpretations in order to pursue more detail responses and ideas, Furthermore, semi-structure interviews draw a guideline between

the two parties on what to talk about and that prevent time consuming, losing control and confusion (Gill et al., 2014). The following questions are the interview key questions that were prepared by the author in order to satisfy the research objectives and guide the interview efficiently.

Question 1: What is your knowledge and opinion about living wall systems?

Question 2: In your opinion, what are the benefits that LWS can bring to the people, buildings and environment in Amman?

Question 3: Do you think that LWS can be an alternative cladding technique in Amman? Would LWS affect the architecture practice and change the way we design our buildings? How?

Question 4: How would the people in Amman receive the idea of covering their building's facades with plants via LWS? Would they like it and accept it or they would reject it?

Question 5: In Turkey, Europe, North America and different places around the world LWS became popular and widespread, but why not in Amman? Why LWS doesn't exist yet in Amman?

Question 6: According to the LWS literature, each square meter of LWS require 3 litres of water per day that approximately 90 litres of water per month, do you think this amount of water is critical in Amman since water scarcity is a real problem facing the city?

Question 7: LWS is an expensive system, the average price of one square meter is between 300-1000 euro, so do you think the cost of the system is an obstacle? And how would it affect the implementation of LWS in Amman?

Question 8: The average life-span of LWS is between 10-25 years, do you think that is challenging the system and considered as problematic? Why?

Question 9: Since LWS is a living system then it requires a very intensive maintenance, how would that affect the implementation of the system?

Question 10: Do you think the weather in Amman specially in summer, would be a real problem for LWS? Why?

Question 11: What are the other factors and challenges that may prevent architects and building owners from applying LWS on their designs and buildings?

Question 12: What are the chances and opportunities of LWS in Amman? How can we overcome its obstacles and facilitate its implementation?

Since there are no LWS experts and LWS specialized company in Amman and Jordan, it was important to interviewed LWS experts from other countries. Therefore, the author prepared another form of interview questions as the following:

Question 1: LWS require intensive maintenance, for many people maintenance is an obstacle and a challenge. As a living wall expert, how do you deal with the maintenance issue?

Question 2: LWS is an expensive system. How do you deal with this challenge? And how can you convince people to install the system despite of its high prices?

Question 3: What are the other challenges and obstacles of LWS? How do you deal with these challenges?

Question 4: What are the opportunities and chances of LWS? How can we pave the way for its implementation?

3.3 SAMPLE SELECTION

A purposive sampling method was applied for the interview samples selection. This method is a category of non-probability sampling technique, the core characteristic of the method is that the determination of sample members is not based on a random selection, but on the member's experiences, relationships and knowledges regarding to a research

subject. Therefore, it develops an in-depth understanding of a central phenomenon (Creswell, 2007). But in order to develop this comprehensive understanding of LWS and its challenges and opportunities, a variety of backgrounds is required to be investigated, since the construction of living wall system is based on broad and multidisciplinary perspectives (Solano, 2016). This is why the maximal variation approach of the purposive sampling method was the chosen approach, which is also known as heterogenous sampling, this approach is based on selecting sample members whose their knowledges, experiences and specialties are diverse and different (Lared, 2018). The following is the selected participants in the semi-structured interviews who were selected based on their professions and its relations to LWS:

1- ***Architects***
2- ***Botanists***
3- ***Landscape architects***
4- ***Stakeholders***
5- ***Decision makers***

3.4 DATA ANALYSIS

Content analysis was used to investigate the information collected from face-to-face interviews. This is the kind of study in which the gathered information is arranged in themes and sub-themes to allow it to be comparable. A main advantage of content analysis is that it assists in moderating and lessening data gathered, resulting in the creation of outcomes that may then be measured using quantitative techniques. Furthermore, content analysis allows researchers to construct the qualitative data gathered delighting the achievement of the experimentations' targets (Langkos, 2014).

4 . DATA COLLECTION

This chapter presents the data that were collected by interviewing 22 participants in Amman and other 5 participants from different cities around the world which are: Istanbul, Antalya, New York and Toronto.

The participants from Amman are architects, landscape architects, botanists, agriculture engineers, green buildings specialists, environmental consultant, living wall system supplier and decision makers. The participants from other cities are all LWS experts and specialists.

The 30-60 minutes interviews were semi-structured interviews that were conducted over three months period of time. The total number of interviews is 23, 20 of them were individual interviews, while the other three interviews were group interviews, contain two or three participants at once. Furthermore, all the interviews in Amman and Istanbul were in-person interviews. The interviews from Antalya, New York and Toronto were conducted via phone calls and email.

All the interviews were audio recorded, in order to avoid any forgotten information. Each interview was transcribed verbatim then coped to a table that categorized the emerged data into four main parts which are challenges, non-challenges, opportunities and other opinions.

Tables (4:1) and (4:2) provide a detail information about the participants' names and Specialties.

Table 4:1: Participants from Amman.

No	Participant's name	Job description
1	Ammar Khammash	Architect and founder of architectural firm.
2	Imad Dabbas	Architect and founder of architectural firm and the director of sustainable architecture department at Jordan engineer's

		association. Founder of “Amman green 2020” initiative.
3	Jeries Hiremat	Architect and project manager at architectural firm.
4	Mudar Khries	Architect and technical manager at architectural firm.
5	Murad Kalaldeh	Architect and academician.
6	Tha’er Qub’a	Architect and academician. founder of architectural firm.
7	Wael Al-Masri	Architect and founder of architectural firm.
8	Yazan Kamel Mahadin	Landscape architect and CEO at architectural and landscape architecture firm.
9	Belal baker	Landscape architect and general manager at landscape architecture firm.
10	Hamzeh Mahasneh	Agriculture engineer and project manager at landscape architecture firm.
11	Morad Al-Beirouty	Botanist and founder of landscape architecture firm.
12	Rasha Samawi	Landscape architect and head of landscape department at architectural and landscape architecture firm. LEED Green Associate.
13	Lara Zureikat	Landscape architect and Associate Director at the Centre for the Study of the Built Environment (CSBE).
14	Murad Abeda	Botanist and founder of landscape architecture firm.

15	Mohammad Asfour	Chairman of Jordan Green Building Council (JGBC). And Regional head of MENA Network.
16	Hala Al-Shouha	Architect and JGBC green academy coordinator.
17	Maha Al-Zu'bi	Consultant at environment ministry and sustainable development, action planning, public policy and governance.
18	Meqdad Rababa	National project manager at UNDP for enabling Greater Amman Municipality apply systemic approaches for sustainable urbanization and resource efficiency.
19	Mohammed Qutesh	Agriculture engineer. Director of agriculture department at Amman Greater Municipality.
20	Maen Zureikat	Agriculture engineer. Head of agriculture section at Amman Greater Municipality.
21	Rand Nsour	Landscape architect. Head of landscape architecture section at Amman Greater Municipality.
22	Mohammed Abu Rouza	Contractor. Green roofs and walls supplier.

Table 4:2: LWS specialist participants from other cities.

No	Participant's name	City	Firm's name
1	Sevinc Ulker	Istanbul	Silvanus
2	Ahu Esinduy	Istanbul	Silvanus
3	Serkan Kanbur	Antalya	Verticalle
4	Gennaro Brooks-Church	New York	Eco Brooklyn
5	Mike Weinmaster	Toronto	Green Over Grey

4.1 INTERVIEWS FROM AMMAN

Table 4:3: Interview with the architect Ammar Khammash

1	Challenges of LWS integration into building's facades:
	- Of course, the cost of LWS is the main challenge, and it is a big problem it is so expensive comparing with other cladding materials, the cost should be almost as same as the conventional materials such as stone, or at least more expensive by 10%-15%, but this cost is a disaster for the system in Amman, with these prices the LWS will be only fantasy and decorative element for rich people. - Another reason is the lack of knowledge and the lack of will among architects and others, there are no specialized people with LWS, there are few attempts from people like contractors who are not experts with plants and green elements - There are no polices to increase the green areas within the built environment, we don't have a clear guide for polices that are based on scientific researches. In addition, there are no incentives from the government to support LWS. - Maintenance is a real challenge of LWS in Amman, we always avoid any methods or materials that require maintenance, people and architects want headache-free and maintenance-free methods and experiences.
2	Non-challenges:

	- I don’t believe that water scarcity in Jordan is challenging the existing of LWS in the city of Amman, because we have a lot of native plant species that don’t require a lot of water to survive. - The climate in Amman is not a challenge at all, again because of our native plant species that can adapt our climate in summer and winter.
3	Opportunities of LWS
	- If the government take the issue seriously and should have the will to support such a project through incentives and tax exemptions. - through private and international organizations who can push hard the government to establish policies that support and encourage the system. - through initiatives and clubs that can encourage the young generation and raise awareness about LWS and its advantages. - Through sponsorships from banks and big companies who can provide a great support for such ideas and projects.
4	Other opinion and thoughts:
	- The landscape education and practicing are disaster here in Amman, they think that landscaping is a decorative practice, even most of the architects are using plants and trees for decorative purposes not for environmental functions such shading, temperature control and other advantages. - LWS is not a decorative element only, it has so many advantages and positive impacts on human, city, nature and buildings. It adds a lot of things to us. - We as human are programmed in our deep cycle to love nature, nature has been to us a survival tool and strategy, and that’s why we see every plants and tree beautiful, but on a contrary, We accuse nature to be destructive around our built environment, there is an enmity in people minds towards plants and trees, like it may causes damages, also bring allergy issue and insects, in addition there is an enmity to the biology itself, we don’t allow our children to play with soil and natural stuff. - We have an issue with our architectural movement in Amman, we don’t like to try or experience new methods and elements. - In Amman we don’t have architects who are courageous to apply new method such as LWS into their design, also the clients don’t accept anything new easily, there few architectural offices who have the courage to try new methods but also it depends on the understanding and the acceptance of the clients.

Table 4:4: Interview with the architect Imad Dabbas

1	Challenges of LWS integration into building's facades:
	- This system is expensive, the cost of it play an important role for its existence in Amman, and i believe that is the main reason why it is not commonly applied in the city, unfortunately many people consider LWS as a fantasy. 350 euro for each square meter is a real challenge and obstacle, and even if we minimize the cost to the half it will remain an obstacle, unless if there will be incentives and tax exemptions. - Here in Amman and in Jordan we don't have an experience in such systems, also we don't have a qualified and specialized people who can install these systems, we don't have the awareness and the knowledge about LWS, most of the people have no idea of this technology. - We don't have a system of incentives that encourage people to invest and apply such systems, the budget of the government is limited, and they consider LWS as a cosmetic or decorative, so due to the limited budget, Greater Amman Municipality (GAM) can't afford the cost of LWS and can't establish a maintenance unite who look after these systems. - one of the main challenges is how to sustain the system, how to keep it alive, so maintenance it the biggest challenge.
2	Non-challenges:
	- water is not an obstacle because if you design the building from the first phase to use or reuse the gray water then you solve the water problem. Yes, we are poor with water, but we have a very successful stories of recycling water.
3	Opportunities of LWS
	- we need a national strategy to support such a system, as well as, initiatives that support and call for LWS, it is everyone responsibility. We should make a pilot projects in many different locations so most of the people can see these projects, but it must be professional and successful projects, in order to convince people, after that we can generalize the idea. in Amman if we want LWS to be successful it should be directed and supported by the private sector by big banks, companies and other private institutions, because the government can't afford the cost of such a system. We need to raise awareness among architects and others about LWS.
4	Other opinion and thoughts:

	we are as initiative ‘Amman Green2020’ we can support such method in order to increase the green areas in the city, LWS seems very promising way to green our city and achieve our initiative goal, because we don’t have a lot of horizontal lands most of them are occupied by buildings, but we have a plenty of vertical surfaces. For example: we as initiative we encourage people to make and construct green roofs by giving them free tanks of water.

Table 4:5: Interview with the architect Jeries Hiremat

1	Challenges of LWS integration into building’s facades:
	The cost is expensive and it is an obstacle. The absence of local supplier is an obstacle. Maintenance is the main challenge; people reject green walls due to their maintenance.
2	Non-challenges:
3	Opportunities of LWS
4	Other opinion and thoughts:
	- when we designed the first green building in Amman, we wanted to integrate LWS into 400 m2 façade. but we couldn’t find a local supplier, so we had to contact with a foreigner supplier overseas, the cost they asked for installing the system was almost 1 million dollars! And that’s is extremely expensive and definitely the client rejected it

Table 4:6: Interview with the architect Mudar Khries

1	Challenges of LWS integration into building's facades:
	- The cost is an obstacle as well as the maintenance cost. - Another challenge is the awareness and the knowledge of architects and landscape architects, most of them don't know about the system. - It is a cultural obstacle, the culture of architecture in Amman is a copy past culture, people don't accept new methods, designs and materials, we don't accept any new materials easily. - The polices of GAM is limited and not creative in order to support the idea of LWS, there are no clear polices or rules that organize and support the practices of landscape architecture, therefore, not for LWS. Also, most of the rules and policies are not based on a scientific studies. - Maintenance is an obstacle, the maintenance here requires people who are experts in this filed to make the maintenance and there are no experts of LWS in Amman, so it's a real challenge.
2	Non-challenges:
	I believe the initial cost of LWS is expensive, but when we look to the payback period and the advantages of LWS, it worthy to integrate it into our design.
3	Opportunities of LWS
	- The key success of this system is to raise the awareness among architects of the system, throughout seminars and lectures that explain the system and its advantages. A support from big companies who can adapt the system to their business, these big companies can raise awareness of this system by installing it, where everybody in the city can see and experience the system. A support from greater Amman municipality, for example, GAM established a guideline for the materials that should be used into building's facades in Amman, so if they include the LWS as cladding material they will encourage the architects and other to apply such system into their designs and buildings, and by doing so they will raise the awareness among architects of LWS.
4	Other opinion and thoughts:
	- I'm afraid that because of the intensive maintenance and high cost of the system people will replace the natural plants with an artificial plant, like what GAM did when they used artificial grass to cover the ground. - It is the role of architects who can convince people to use LWS into their facades.

Table 4:7: Interview with the architect Murad Kaladeh.

1	Challenges of LWS integration into building's facades:
	- The cost of the system is extremely expensive, people can't afford it, it is the biggest challenge. - Another main challenge is the lack of knowledge and experience among specialists in the filed of green architecture, many related projects in Amman have failed due to the lack of knowledge, experience and awareness. - the rules and policies form the GAM are an obstacle, I believe that there is no rules or policies encourage architects to integrate plants within their designs. - The biggest problem is water scarcity in this country, we don't have enough available water, according to my information, in the near future, the government will establish strict rules which will enforce us to limit our usage of water, and that's of course a real challenge for LWS. - Maintenance is challenge, people don't like it.
2	Non-challenges:
3	Opportunities of LWS
	- Through grants and initiatives, we can pave the way for LWS in Amman, for example: recently, Amman received a grant by 37 million dollars from the European bank, the aim of it, is to encourage Amman city to be a green city. - I'm sure if there are a legislation which support such practices that will encourage architects and others to adapt LWS into their work. - The reuse of grey water is a perfect solution for water sacristy, in instead of waste this water we can use it to irrigate the system.
4	Other opinion and thoughts:
	- Integrating plants within architecture or building will lead to a creation of landmark in a city, such as the housing bank complex in Amman. due to the use of plants in that building it made a landmark in the city and people still remember the building and aware of it just because of plants.

Table 4:8: Interview with the architect Tha'er Qu'ba

1	Challenges of LWS integration into building's facades:
	We are a poor population and country so we are a cost oriented, so the cost of the system is a challenge here. Cultural challenge, Jordanian people don't accept anything new easily. Always new system and materials enter the country lately. The most important thing to the people in Amman is the durability and sustainability of the system, they don't like anything that needs a maintenance. There is no awareness among architects and clients in such a system! There are neither incentives nor polices from the government to support the LWS!
2	Non-challenges:
	Water is a challenge in Amman, but people solve this problem by constructing water tanks that collect rainwaters, and they use these waters for landscape.
3	Opportunities of LWS
	In order to convince people, you have to link LWS with economic benefits such as, reduction of energy consumption, as well as, the payback period. Incentives are what encourage people to make LWS. Establishing a policy that help to encourage people to make LWS. Raise awareness among people by educating them at universities. Our climate and sun are very hot and dry, so we need to protect our buildings from direct sun light to avoid many problems, and LWS seems to do so.
4	Other opinion and thoughts:
	As an architect, I have no problem to integrate LWS into my design, because it will add many advantages to my design such as an insulation layer, aesthetic view and it is an environmentally friendly approach. For me as an architect, it is important for me that the system is flexible to be added in my design. Flexibility is important.

Table 4:9: Interview with the architect Wael Al-Masri

1	Challenges of LWS integration into building's facades:
	The economic situation is a challenge here in Amman. The expensive cost of LWS is an obstacle. The lack of knowledge and awareness is the main reason why LWS isn't well known in Amman. Maintenance is another main obstacle facing LWS, it requires irrigation and care of plants and we don't have the knowledge of this system so maintenance is a problem here. The sustainability of LWS is another challenge, because most of people understand architecture as a permanent product or material, so I don't believe LWS can be accepted as alternative cladding material.
2	Non-challenges:
3	Opportunities of LWS
	The most important thing to people is the cost! Cost must be appropriate to people in order to accept it. So, we must link the idea of LWS with economic advantages, such as reducing energy consumptions where people can save money out of it. Or by providing incentives for the buildings whose integrate LWS into their facades. - It should be adapted by big malls and companies and government; those can pave the way for LWS to be accepted by the general populations.
4	Other opinion and thoughts:

Table 4:10: Interview with the Landscape architect Belal Bakeer

1	Challenges of LWS integration into building's facades:
	The real challenges are lack of knowledge and awareness. Maintenance is a real challenge, so that's why people applied artificial plants in order to avoid the intensive maintenance, even the cost of the artificial plants is more expensive. There are no policies or incentives to support the LWS.
2	Non-challenges:
	The climate atmosphere is wonderful in Amman for the plants, we have a diversity of plant species that are suitable for Amman climate, so the weather is not an obstacle. The amount of water the system needed is not too much. Water scarcity is not a problem.
3	Opportunities of LWS
	Raising awareness among people, architects and landscape architects about LWS. An encouragement from the government through policies and incentives. A support from big companies, they should adapt LWS in their buildings. Because they are capable to adapt the system. There should be a marketing plan for the LWS, to raise everybody awareness about it.
4	Other opinion and thoughts:
	we have been working in landscape architecture since 1970s, so if we found a good potential in these systems, we will use them but we still have no knowledge about them.

Table 4:11: Interview with the landscape architect Hamzeh Mahasneh

1	Challenges of LWS integration into building's facades:
	- The cost of the LWS is an obstacle, it is expensive, if people in Amman are capable finically, they will make green wall, but cost must be appropriate for most of the people in order to make it. - Landscape architects are not aware of system and they don't have the knowledge of it. Also, the people in Amman have no idea about it. - It requires a lot of maintenance which people don't like. - There is no support from GAM. They also aren't aware of the system. - We have a problem with water, we are poor with water, people are avoiding green areas in their houses in order to save water.
2	Non-challenges:
	- In case of LWS since we use an artificial media, we consume less water than the traditional planting, natural soil absorbs more water than the artificial one and by the use of hydroponic system for irrigation we consume less water so, water is not a problem for LWS. - The climate in Amman is not problem especially if the plants took a good care such as fertilizing, nutrients and maintenance specially in summer.
3	Opportunities of LWS
	- Amman Great Municipality should promote the system, and they will help to pave the way for living wall application in the city, they are capable to do it. - Landscape architects should be educated about the LWS, and we should raise people awareness about the system, its applications and advantages.
4	Other opinion and thoughts:
	LWS add points for green building certificate.

Table 4:12: Interview with the landscape architect Lara Zurigat

1	Challenges of LWS integration into building's facades:
	The expensive Cost is an obstacle besides the maintenance cost. Maintenance is the biggest challenge. Lack of knowledge is a main challenge.
2	Non-challenges:
	water is not a challenge since these systems are based on hydroponic system then they consume less water. Weather isn't a challenge; we have a lot of native plant species that adapt the weather in Amman.
3	Opportunities of LWS
4	Other opinion and thoughts:
	I don't like LWS, it is only a decoration.

Table 4:13: Interview with a Landscape architect Morad Al-Beirouty

1	Challenges of LWS integration into building's facades:
	The cost is the main challenge that prevent LWS to exist in Amman, because it is a new technology so that is why it is expensive. In addition, the economical situation in the country is bad, so that's the main obstacle for any new technology in Amman. Another challenge is the people awareness, the majority of the people haven't heard about the system. Maintenance is another main challenge.
2	Non-challenges:

3	Opportunities of LWS
	- Green buildings are becoming trending here in the city, as we know LWS add point to green buildings, so that seems to be a promising opportunity for LWS. So, we should add LWS into the policies of green buildings codes. We can solve the problems of LWS by experience. We have to experience the system here in Amman, and of course the problems will show up, and then by experience we can work on a solution. Policy makers can play an important role to support and pave the way for LWS implementation in the city, through polices and incentives that encourage people to have the or apply the system. The most important thing is that people who work with system must be well educated and professional.
4	Other opinion and thoughts:
	people always are worry when dealing with plants, they have many concerns, we should raise the awareness among people of LWS in order to be accepted by them.

Table 4:14: Interview with the Landscape architect Murad Abeda

1	Challenges of LWS integration into building's facades:
	Cost is the main obstacle and challenge, LWS is so expensive because it is a new method and there is no alternative way that may decrease the cost of it. One of the real challenges, is how to maintain the plants alive. people lack the knowledge and awareness about LWS and it advantages. Importing the elements is another challenge, because importing increase the cost, we still not aware of the local elements that we should use for the system.
2	Non-challenges:
	There is diversity of native plants that adapt the weather in Amman, so weather is not an obstacle.
3	Opportunities of LWS

	Marketing and advertising are tools to educate the people and raise their awareness about LWS. Big companies can play an important role for paving the way of LWS installation. Localizing the system, using local materials in order to decrease the cost.
4	Other opinion and thoughts:
	We are working on a big vertical garden in Amman for hospital the area of the green wall is 200 square meters. Who convinced the owner of the hospital to construct a green wall? The designer the architect.

Table 4:15: Interview with the landscape architect Rasha Samawi

1	Challenges of LWS integration into building's facades:
	Cost is a real challenge, specially here in Jordan because of the economic situation of the country. The biggest challenge is the maintenance! In Amman there is no rules or polices that advise or tell you to add LWS into your design, the rules don't tell you anything about the green areas and how much should we plant nothing is clear. In case of the clients they don't have a knowledge about the LWS, they are not aware of the system so they don't tell you to add it to the design. Another important challenge is that the awareness between architects and designer is not enough about the available systems in the market and worldwide. In many cases the contractors are the one who are looking for new methods and systems not the architects.
2	Non-challenges:
	About the climate, the climate is not a problem or a challenge, because we have many plants that can adapt our climate. Water scarcity is a real challenge in Amman, but comparing between the irrigation for LWS and for conventional way, LWS consume less water so I don't think water is an obstacle for LWS.
3	Opportunities of LWS

	It is so important that these systems are tested in Amman environment and installed successfully in order to convince people. It must be a professional work. Education start from schools and then universities, it's a responsibility for universities and the engineer's association to educate people and also to raise the awareness. In GAM they start to give incentives for green buildings, this can encourage the system, but again there is no clear polices. So, we should establish clear polices and encourage people by incentives. International organizations should push the Jordanian government to adapt polices to encourage the integration of LWS within built environment. These systems should be available in the market at any time so that facilitate its construction, better than importing from outside the country.
4	Other opinion and thoughts:
	For many projects we designed we proposed an LWS at the concept phase but later the clients and contractor ignore the idea of it in order to reduce the cost. people in Jordan and in our neighbouring countries are used to be surrounded with plants, if look at our traditional architecture you find that we used to design an inner courtyard that is full with plants, so we love have the relation with plants. And this built in our subconscious mind.

Table 4:16: Interview with the architect Yazan Kamel Mahadin

1	Challenges of LWS integration into building's facades:
	We don't have the knowledge about the systems of green facades, people don't understand the work of landscaping. Architects and landscape architects are not aware of LWS. There is no polices and legislation support such a system, also there is no cooperation among other parties, all of them work individually. Cost is the main challenge. Maintenance also another main challenge. But it is also depending on the plant selections, because some plants don't require a lot of maintenance specially the native plants which grow in Amman by its self. we don't have experience in this field.

2	Non-challenges:
	Is water a problem? No at all, yes Jordan face water scarcity issue but not for this system, we can manage the water usage for this system.
3	Opportunities of LWS
	Educating the people and raise their awareness. LWS should be included into a polices that support its exciting in Amman and facilitate the way for its implementation. Through constructing big projects which can be a landmark project, but it must be professional work.
4	Other opinion and thoughts:

Table 4:17: Interview with JGBC representatives (Mohammad Asfour and Hala Al-Shouha)

1	Challenges of LWS integration into building's facades:
	Cultural challenge, anything new in architecture in Amman isn't easy to be accepted, starting from the architects themselves so what about the general public. We don't have the knowledge about it, we don't have specialized people to construct such a system, and we don't know the technical details of the system. People are not aware of such a system. Knowledge is the main challenge! People in Jordan don't like any system that require maintenance, so they avoid any thing require maintenance, so Maintenance is the biggest challenge, we don't have the culture of maintenance. Another challenge is the lack of policies and incentives. 3 Litre per day is a critical amount of water, water is a real obstacle in a city like Amman.
2	Non-challenges:
	we can reduce water consumption by using native species that don't require a lot of water, also grey water can be a solution, so water scarcity is not an obstacle for LWS.

3	Opportunities of LWS
	As we raised the awareness of the people in Amman about green building, we can follow the same step for green walls, firstly: we should have a pilot project a successful green wall/façade so we can show people that this system is working and efficient. We should link the green wall with economic benefits business case (people), as well as, benefit for the city and the environment and this will affect the (policy makers). We should also educate people or raise their awareness of this system by courses seminars and lectures through different institutions such as universities engineer associations.
4	Other opinion and thoughts:
	Stone cladding material is very harmful to the environment, so if you can make LWS as an alternative cladding material which will reduce the usage of stone material then have done a great job to the environment.

Table 4:18: Interview with Dr.Maha Al-Zu'bi

1	Challenges of LWS integration into building's facades:
	The expensive Cost is one of the main challenges. The incentives from the government is not available which may consider as a problem. The decision-making process inside GAM sometimes it is based on personal interest not on professional interest. Water is challenge! 3-5 litre is critical in Amman? Of course, the city is poor with water resources it has only two water sources, water consumption is priority for human usage and manufacturing not for green areas and vertical gardens. Lack of coordination between different parties and institutions is a challenge. Maintenance is a real problem, the real challenge here is sustaining the system. lack of knowledge, also lack of technology, as well as, the absent of local manufacturing, therefore, we have to import everything and that add more cost.
2	Non-challenges:
3	Opportunities of LWS

	we need a leadership in our governmental institutions to push forward for such projects, we need people who understand its impacts socially, environmentally and economic for the city. Policies that encourage the application of these systems. Climate change impact on Amman is an opportunity not a challenge for LWS, because this method is able to mitigate the urban heat island, also filtering the air and absorb the toxic gases, so it is an opportunity that need to be applied in Amman in order to face the climate change. Some of the solutions for water scarcity is the use of a native plants or other plants that don't require a many amount of water. Another solution, is to create water tanks that collect rain water, these collected water can be used for landscape and also irrigating the green walls. Through initiatives which explain and raise awareness about LWS and its advantages.
4	Other opinion and thoughts:
	The council of GAM may support such a system if there is a personal interest, and if there is a conflict of personal interest, they may push back! Few years ago, a company specialized in green roofs and walls in Amman has established but it failed down, the company faced three main challenges such as the acceptance of stockholders to integrate LWS into their buildings, the policies of GAM were not clear and supportive and water challenges! There is a project within the GAM that is supported by the UNDP which it is main aim is to minimize the energy consumptions within buildings, and they provide/ allow an extra floor for buildings who follow the regulations and rules that reduce energy as incentives. The environment ministry fund projects that have a positive impact on the environment, and it may fund LWS on public buildings if it is approved that it has a benefit on the environment. Building's owners want to get incentives in order to apply the system. But the general population would like to see green wall in front of them rather than a concrete or stone wall/façade.

Table 4:19: Interview with a project manager Meqdad Rababa

1	Challenges of LWS integration into building's facades:
	The main reason and challenge that LWS isn't commonly used in the city is due to the lack of awareness among people. second reason is the water scarcity in Jordan, we have problem with water, where the city of Amman doesn't receive water continuously (daily), people receive water once or twice a week, I believe irrigating LWS with water will not be a priority for people due to water scarcity issue. The initial cost of system with the cost of water bills makes the system not efficient, cost is a real challenge here. the continues water irrigation and its bills is the problem here in Amman, unless if the system can drop the cost of electricity!
2	Non-challenges:
	Our weather is dry that increase the percentage of the evaporation which leads to more water consumption, so I believe it's a challenge, except if we use native plants that don't require a lot of water and can adapt our climate.
3	Opportunities of LWS
	Through projects like my project where we can make a pilot project and support such projects if the system is economically efficient, for example: if LWS can reduce the energy consumption and can be successful investment. throughout governmental projects and initiatives which aim to care about the environment. Throughout a support from international organizations which support any project for sustainable development in developing countries like Amman.
4	Other opinion and thoughts:
	People don't care about the environmental advantages of the system such as filtering the air, what people care about it the investment of the system, for example: reducing the electricity bills, the system must have an investment in order people accept it with these prices. Due to the lack of knowledge about plants, the GAM replaces a native plant with imported plants which require more water, due to that the bill of irrigation increased, and today GAM pays annually 400.000 JD only for irrigation.

Table 4:20: Interview with GAM representatives (Mohammed Qutesh, Maen Zureikat and Rand Nsour)

1	Challenges of LWS integration into building's facades:
	Cost is a challenge and an obstacle. Even if the cost of LWS is equally the same with conventional materials, still you the maintenance cost for LWS, where conventional materials don't have a maintenance cost. That is a real challenge. Lack of Awareness and knowledge among people and specialists. At the moment there is no policy for LWS, no intensives because we have no experience and we don't know about it.
2	Non-challenges:
	3-5L/m2/DAY is not too much water, we use much more than this amount to irrigate one tree.in addition, we can use plants that don't require much water. The weather is too not a challenge, it is correct that our weather is dry in summer, but we have a lot of plants that can adapt the weather, so isn't a problem.
3	Opportunities of LWS
	private sector should lead the process and then we can support them, as well as the professional associations. it can be supported by initiatives, also by international organizations such as UN, WORLD BANK and others.
4	Other opinion and thoughts:
	The expensive cost of the system will make it exclusive only for rich people, not for the general public.

Table 4:21: Interview with Mohammed Abu Rouza

1	Challenges of LWS integration into building's facades:
	we don't have specialized people to apply LWS and that's the main reason why LWS isn't well known in Amman, and that's why many attempts of installing LWS has been failed. Lack of knowledge and awareness of LWS. The economic situation of the country is bad and that of course plays an important role, so the cost of the system is a challenge. we don't have the culture of maintenance, and this system require a lot of maintenance, people want a free maintenance system something like plastic green wall. In addition, the cost of the maintenance is another main challenge.
2	Non-challenges:
	Weather isn't problem, because of the right plants selection which can adapt the weather.
3	Opportunities of LWS
	GAM should adapt and support the system in order to be successful in the city. Architects should apply the system into their designs. through the universities by giving a course and seminars that raise the awareness among people, architects and other.
4	Other opinion and thoughts:

4.2 INTERVIEWS FROM OTHER CITIES

Table 4:22: Interview with Silvanus company representatives (Sevinc Ulker and Ahu Esinduy)

1	Challenges of LWS integration into building's facades:
	Cost is a challenge, most of our clients are rich people, big companies and municipalities who are capable financially to afford the cost of the system, because it is very expensive.
2	Non-challenges:
	Water is not a challenge.
3	Opportunities of LWS
	Raising architects' awareness is an opportunity, when we start, we were approaching architects to tell them about LWS, now they approach us asking us to cooperate with them to integrate our products to their designs. Big companies support is great way to raise the awareness of LWS, by applying LWS into their buildings where it can be seen by all the people.
4	Other opinion and thoughts:

Table 4:23: Interview with Verticalle company representative (Serkan Kanbur)

1	Challenges of LWS integration into building's facades:
	Irrigation systems and their pipes are our main challenge. Maintenance is a challenge, but we try to follow low maintenance strategies in order to minimize the maintenance. The challenge with cost is both the installation cost and maintenance cost
2	Non-challenges:

3	Opportunities of LWS
	Eliminating the maintenance and its cost is a great opportunity for these systems, so we trying to provide guarantees for the maintenance. And that helped us a lot. Moreover, applying low maintenance strategies can help a lot.
4	Other opinion and thoughts:

Table 4:24: Interview with Eco Brooklyn company representative (Gennaro Brooks-Church)

1	Challenges of LWS integration into building's facades:
	Other LW companies consider maintenance as their business model to make money on the maintenance, that is a challenge because it increases the total cost of the system. For me the biggest challenge is when the technology fails, for example, sometimes the irrigation pipes break and that's because they were not made well. Another challenge is the technical and mechanical problems, were sometimes the equipment fail such as the pump, the timer and other stuff. The cost of LWS is expensive and it's our challenge in this field, as company we have tried to reduce the cost of the system, but we couldn't find a way to do it.
2	Non-challenges:
3	Opportunities of LWS

	We always try to construct a system that require very little maintenance, according to my experience in LWS is that if you get the watering right, the system will not need much maintenance, for example I have constructed a LWS five years ago and I haven't touch it till today because the watering is good, so providing the needed amount of water the plants required is the key solution for the maintenance. I think if the people understand the value of the LW, they will see it worth the money or at least worth spending more money than what they think. It is a powerful thing to have LWS in your building and your living space, it is really changed my life and I would easily pay that price. I think it is important to change people perception of the value of the wall, they think it is expensive because they don't know how valuable it is. one of the solutions to the pricing and the cost of maintenance is by providing incentives and support from top governmental level.
4	Other opinion and thoughts:

Table 4:25: Interview with Green Over Grey company representative (Mike Weinmaster)

1	Challenges of LWS integration into building's facades:
	The only challenge is the limits to creativity. The main thing that makes living walls more expensive is the infrastructure required to keep the plants alive.
2	Non-challenges:
	Our company offers maintenance programs for our walls so the clients do not have to worry. We keep the walls looking good all the time and replace plants when required. Our system is completely automatic (automatic lighting, watering and nutrients) so it actually makes it much easier to care for than a potted plant. Being hydroponic and having unlimited space for the roots to grow and spread throughout the system, plants will grow healthier and reach their full potential.
3	Opportunities of LWS

	The beauty and health benefits are a way to convince people to have a living wall. Large companies like Microsoft, Amazon, Google, etc have found that by putting in living walls (and greenery in general) in the work space it makes the employees happier which leads to less 'sick' days and in the end actually ends up saving a lot of money. The city of Toronto has passed a bylaw that says that every new building over a certain size must have part or all of the roof covered in a green roof. If similar laws were passed for living walls then this would help the industry to grow. Using a large diversity of plant species that flower (and produce berries) is a great way to bring biodiversity into the city. The living wall will then be a great supply of food for urban bees, butterflies and hummingbirds.
4	Other opinion and thoughts:
	If people have an issue with looking after plants then they perhaps should not have them. Plant can be seen as pets and if you have a dog you can't expect not to feed it or take it for walks.

5 . DATA ANALYSIS AND DISCUSSION

This chapter presents the analysis of primary data and the discussion between the analysed data and the secondary data.

The data analysis was based on thematic coding system, which categorized the data under several themes and sub-themes, each theme represents a different perspective on a specific issue that was delivered by the participants. However, four main themes were established as findings of this thesis, each one of these contain two or three sub-themes. The following shows the main four themes and their sub-themes:

a. Cultural obstacles
    i. Culture and mentality
    ii. Lack of awareness
    iii. Lack of knowledge
b. Lack of encouragement
    i. Lack of polices and rules
    ii. Lack of incentives
    iii. Lack of coordination
c. Cost
    i. Initial cost
    ii. Operational cost
    iii. Maintenance cost
d. Technical obstacles
    i. Maintenance
    ii. Water

5.1 CULTURAL OBSTACLES

Challenges

According to the majority of the participant in the interviews, “culture, lack of awareness and knowledge” are the main factors that are challenging living wall systems, their existing and their integration into building’s facades in Amman.

Based on participant’s opinions, people and architects in Amman are not aware about the existing of LWS, they don’t know about them and have no idea that there are methods such as LWS which are capable to integrate plants vertically into building’s envelopes. Furthermore, the minority of architects who know about LWS, they consider them as decorative materials only, where they are not aware of LWS advantages and their positive impact on humans, buildings and the environment. So based on this perspective it is obvious why LWS is not commonly used in Amman.

Many of participants claimed that the dominant culture is the main reason for lacking the awareness and knowledge about LWS, where they are referring to the culture of the people and the architectural culture of architects in Amman, whereas people don’t accept new methods and materials easily, they adhere to traditional architecture and materials and they don’t search for new methods, architects in Amman are part of this culture and they are influenced by it, so it is hard to notice a change in the architectural language in Amman, where almost all the architectural outcomes are alike. Therefore, many of the participants described the architecture in Amman as ‘copy paste architecture’.

Additionally, a comparison done by the architect Wael Al-Masri who has been working between Amman and the Arabian gulf states since three decades, where he compared between the two cultures, he claimed that the clients’ culture in the gulf is always inclined towards new methods and techniques. Therefore, they always ask architects to design a unique and new designs that have never done before, so this mentality and culture is always encouraging architects to look for and follow up to all what is new in the this filed. On the other hand, the clients’ culture in Amman is always adhered to the traditions and what is already known, so they ask architects to re-design works that are already excited in Amman. Therefore, this mentality and culture hinders and limits architects to search

for new methods and techniques, and that's the reason why many architects in Amman are not aware of new materials, systems and methods, which leads the architectural movement in the city to be an idle movement or lazy architecture as many participants described it.

The architect Ammar Khammash stated that: "we have an issue with our architectural movement here in Amman, most of architects don't have the courage to apply new methods and techniques into their designs".

He refers to the architects who are aware and have the knowledge about new technologies and materials, but they don't have enough courage to reflect these new approaches into their works, because they are limited by the mentality of the clients, also they fear the client's rejection, therefore, losing the job and that's why they don't like to try new experiences. But then he added: "There are few architectural offices in Amman who have the courage to try new methods in their works and they try to convince the clients to accept new materials and approaches, but it is based on the understanding and the acceptance of the clients, which is the real challenge".

Also, the architect Mudar Khries stated: "we always try to adapt new materials into our designs, so we included LWS into our different designs, but it was refused by the clients who always ask us to replace it with conventional materials like stone".

Based on the above quotes, it can be argued that people culture and mentality is an obstacle facing the integration of LWS into building's facades, where it is hard to convince people to apply new methods such LWS. Moreover, architects, landscape architects and LWS suppliers always suffer to convince clients to apply LWS, due to the lack of knowledge of living wall and its many advantages which is a challenge that hinders the implementation of the system (Jaafar et al, 2011).

Client's mentality and awareness are challenging the existing of LWS in Amman. However, most of the participating architects claimed that, clients are not responsible to be aware of the system, it's the architect's responsibility to have the knowledge about different methods and materials, they are the one who should always search for new approaches and techniques not the clients. So, it is the responsibility of the architects to be aware of LWS and to know its details and advantages, who are able to convince the

clients to integrate LWS into their buildings and raise their awareness. As the architect. Mudar Khries claimed: “It is the role of architect who can convince people to use LWS into their facades. The architect can tell people about the many advantages LWS can provide, such as the building visual impact, insulating the buildings and other advantages”. Based on that, the lack of knowledge and awareness of LWS’s products, functions and benefits among architects and others specialists is the main issue that hinders the implementation of LWS in Amman.

Unfortunately, LWS and its advantages towards human, city and the environment are not broadly acknowledged, there is a general lake of knowledge and awareness of LWS among clients, architects and landscape architects. Also, the conducted researches about LWS is still minimized and limited. Therefore, lack of knowledge is the main challenge when it comes to LWS which limits its implementation (Tzortzi et al, 2014).

Another challenge facing LWS in Amman, which is considered as the main reason for the lack of awareness and knowledge, is the absence of experts and specialists of this field in the city, till todays there is no specialized company that construct and install LWS in Amman, therefore, there is no marketing for the system among architects, landscape architects and people, which is the main reason why architects lack the knowledge about LWS. Moreover, another obstacle is caused by the absence of specialized companies is the availability of the systems and its components locally, which force the architects who want to apply the system into their works to communicate with specialized companies overseas and that of course a real obstacle for LWS in Amman where the availability of the system locally is very important to pave the way for its installation. As the architect Jeries Hiremat stated that: “we wanted to integrate LWS into a full façade for a building we designed, but we couldn’t find a local supplier, so we had to contact with a foreigner supplier overseas, but for many reasons we canceled the idea of LWS”. Based on that, the absence of experts and specialists is the main reason for the technical and knowledgeable obstacles facing LWS.

There are few people who are installing LWS in Amman mostly they are a contractors or gardeners, but they are not specialized and have no experience, generally they import the components of LWS and sell as products not as an integrated system, Moreover, the majority of their works failed due to the lack of experience and knowledge.

The architect Murad Kalaldeh claimed that: “I was a consultant for many related projects, the integration of plants into buildings, all of projects didn’t succeed, because the suppliers lack the knowledge and experience”. so the results of these projects is certainly unprofessional and that’s what create another obstacle, and will make it hard for people to accept it, because according to the majority of the participants, it is important the work of LWS must be professional and successfully experienced in Amman in order to convince people and get their acceptance. Moreover, based on the literature review, the negative public’s impression about LWS and green roof is caused by the practices of inexperienced companies who make mistakes and provide poor quality systems and materials. This kind of poor-quality works is a real challenge that negatively affect the entire industry (Afrin, 2009).

Another issue faces LWS is that, culturally people have concerns and fears when dealing with plants around their buildings. As the architect Ammar Kammash claimed: “We accuse nature to be destructive around our built environment, there is an enmity in people’s minds towards plants and trees, like it may cause damages for their buildings”. So, based on this mentality, people isolate their buildings away from plants and trees, because they want to avoid moisture and cracks issues in their buildings which can be occurred by the plants. So, this understanding of plants and its relation to built environment is a challenge to the integration of plants into building’s facades though LWS. However, the literature review disagrees with previous perspective. It is right that plants and trees cause cracks and moisture issues for buildings, but in case of LWS that’s impossible to occur due to a 5-10cm air cavity that physically separates the structure of LWS and the wall of the building, which prevent plants to have a direct connection with the building. Therefore, prevent any negative events to occur. Furthermore, LWS works a protection layer that protect the building form climatic factors such as rain, snow and moisture (Perini and Ottele, 2018).

Opportunities

The opportunity of LWS through the cultural obstacles is simply by raising the awareness and knowledge of LWS and its benefits among architects, landscape architects, clients and decision makers. Moreover, based on the interviews analyses, architects are the key success of the dissemination of LWS, because they are able to convince clients to apply

living walls on their buildings by informing them about the benefits that they and their buildings gain by applying such a system into their building's facades.

Mainly there are two ways that help to raise the architects' awareness and knowledge of the system. Firstly, through education by providing courses, seminars and workshops which help to educate architect and landscape architects about LWS and its benefits, so it is the responsibility of universities, educational centers and the Jordan engineers association to provide seminars and lectures, as Jordan green buildings council's representative stated that: "We should educate architects and people and raise their awareness of this system by courses, seminars and lectures through different institutions such as universities and the engineer associations". Secondly, through involving LWS into building construction guidelines and codes which is lunched by the greater Amman municipality (GAM), these guidelines can raise the awareness of architects and clients of LWS, as the architect Mudar Khries stated: "Recently, GAM established a guideline for the materials that should be used into building's facades in Amman, so if they include the LWS as cladding material they will encourage the architects and other to apply such system into their designs and buildings, and by doing so they will raise the awareness among architects of LWS".

The architect Emad Dabbas stated that: "At the beginning people will not understand the system, you should convince them by many ways, for example by a pilot project specially on public buildings where are visibly for many people". Another great opportunity to raise the awareness of LWS among the people in Amman is through big public LWS projects or pilot projects that is implemented professionally and successfully. These projects can be funded by the government or by the support of big companies, such projects are visible by all the people which are able to raise their awareness.

5.2 LACK OF ENCOURAGEMENT

Challenges

Lack of encouragement is another main challenge that is facing the integration of LWS into building's facades in Amman, according to all the participants, LWS is new technology in the city, so it needs an encouragement and support from both the public and private sector, specially due to its many advantages for the city, humans and the environment. Unfortunately, LWS lack the encouragement in Amman, which hinders its implementation in the city. Based on the participants opinions lack of encouragement is presented in three main ways, which are: "lack of policies and rules, lack of incentives and lack of coordination.

Rules and policies are very important ways for encouraging people to follow new regulations and technologies, and through them we can encourage architects, landscape architects and clients to apply new systems and materials into their designs and buildings in Amman. The greater Amman municipality (GAM) is the responsible for organizing the architectural and landscape practices, through establishing policies and rules related to buildings, materials, green araes and other related subjects. The landscape architect Hamzeh Mahasneh stated: "Amman great municipality should promote the systems of living walls, they can help to pave the way for living wall applications in the city, because the municipality is capable to do it". Based on that, GAM is capable and able to encourage people and architects through rules and policies to apply new systems and materials into their buildings such as living wall systems which have positive impact on the city, humans and environment. Moreover, many cities around the world are adopting living wall systems into their rules, polices and plans in order to fight climate change and other environmental issues, due to the efficiency of LWS in addressing these issues, such as: reducing greenhouse gas emissions, mitigating the urban heat island effect, reducing energy consumption and stormwater management (Hopkins et al, 2010).

In Amman, there are no policies that encourage people and architects to integrate LWS into their buildings. It is considered by all the participants as an obstacle and a challenge facing LWS in Amman. As Dr.Maha Zu'bi claimed that: "Few years ago, A friend of

mine, established a company that is specialized in green walls and roofs, but the company failed, and one of the main obstacles the company faced was that, rules and policies were not supportive and clear". Based on that, rules and policies play an important role on the existing of LWS in the city, Moreover, GAM also, haven't establish a policy that tells architects about the percentage of green areas within each project. Therefore, they don't encourage Architects to include green areas into their building's designs. So, architects are not motivated to search for new methods and systems such as: LWS and green roof systems which help them to increase the green areas within their works. Furthermore, the literature review of LWS agrees with the previous perspective. Whereas the lack of governmental policies and guidelines that encourage the implementation of LWS, is one of the main factors that limits the dissemination of living walls on a bigger scale and hinders the development of the entire industry (Giordano et al, 2017).

Another challenge that is facing LWS in Amman is the lack of incentives. According to the architect Emad Dabbas: "here in Amman, we don't have the system of providing incentives that encourage people to apply LWS in their buildings". So, according to the majority of the participants, lack of incentives is one of the reasons why LWS isn't commonly used in the city, where incentives is very effective way that encourage and motivate people to adapt new methods like LWS. Moreover, Singapore has been witnessed an enormous increase of LWS applications in the last decade, due to an incentive program that has been lunched in 2009, which encourage the integration of LWS into building's facades, by offering 500$ per square meter for existed and new buildings who install LWS. Since then, 110 existed buildings have been applied LWS and an enormous increase of the implementation of LWS within new buildings and skyscrapers (Giordano et al, 2017). Based on that, it can be argued that, incentives can pave the way for implementation of LWS. So, without incentives people in Amman wouldn't be motivated to apply LWS into their building's facades, and that is an obstacle, as Wagemans (2016) stated that: "living wall systems are not implemented in the building industry on a large scale. This is mostly due to the lack of implementation guidelines and incentive programs".

Lack of coordination between different entities is a challenge that hinders the application of new methods. According to the participants who work within GAM, they stated that: "We haven't established policies neither incentives that support LWS, because we don't have experience of LWS and we lack the knowledge about this new technology. On the another hand, it is also a responsibility of other players such as: the private sector, organizations and universities where they should provide us with the data and researches that approve the efficiency of LWS, then we can cooperatively support LWS in many ways". Based on that, there is a lack of communication between different parties and that may block the way for new technology like LWS. Many participants claimed that: "All the institutions lack the coordination between them, they work separately, and that's is a challenge for LWS which may limit its opportunities". So, through coordination and cooperation between all the players can result in cooperative works which help to pave the way for LWS, such as: seminars, workshops, as well as, pilot projects that raise the awareness of the people and specially decision makers which may establish polices and rules that encourage the implementation of LWS.

Opportunities

There are many opportunities for LWS in Amman, which can be achieved through many ways that can encourage people, architects and landscape architects to apply LWS into their buildings.

The most effective opportunity is the governmental support which can be done by the establishment of policies and legislations that encourage people and architects to install LWS and also raise their awareness, as the architect Murad Kalaldeh stated that: "I'm sure if there are policies that support such practices that will pave the way for its implementation in the city". Another support that the government can achieve is through providing incentives which are great opportunity for LWS. The architect Emad Dabbas claimed that: "Any kind of incentive motivate people to accept and apply new methods, for example: Amman green 2020 initiative which is supported by GAM, gave people who apply green roof systems a free tank of water monthly, and that encouraged people", so incentives are a motivation for new technologies. Furthermore, between 1983 and 1997; a 245,584 m2 of green facades was applied in Berlin. As a result of, developing

regulations and incentive programs which encouraged the installation of green facades (Kohler, 2008).

Additionally, GAM has started to give building's owners a permission to construct extra one floor as an incentive, if their buildings get a green building certification. According to the project manager Meqgag Rababa who claimed: "One extra floor as an incentive equals thousands of dollars and even hundreds of thousands of dollars in some expensive areas". Moreover, LWS adds points to the LEED certification. So, including LWS in green buildings requirements and codes is a great opportunity for the system in Amman, specially that green buildings are becoming a trend in Amman. However, From the literature review related to LWS, it shows that LWS earn directly two LEED credits and positively affect additional thirty points (Weinmaster, 2009).

International organizations who support environmental and sustainable programs can provide a huge support and opportunity for LWS in Amman, whereas, these originations can provide loans and grants for Amman and help the city to get more support form donor countries and international institutions such as: the United Nations, so they can affect the policy-making process in GAM and able to push hard the Jordanian government to establish rules and policies that encourage the installation of LWS in the city.

5.3 COST

Based on the analysis of the participant's interviews. It is clear that cost plays an important role for the existing of LWS in Amman, where the expensive initial cost, besides the operational cost of LWS, hinder the way for the system to be a common cladding material in the construction industry in Amman.

Challenges

Jordan as a country faces a serious economic challenges, which makes the acceptance of new technologies rely on the cost. Therefore, the prices of new technologies must be appropriate to the economical situation of the people in order to be accepted. LWS is a new technology and it is very expensive which is definitely an obstacle for the system in Amman. The architect Tha'er Qu'ba stated: "We are poor community, so we are cost

oriented. Therefore, people won't apply LWS because of its expensive cost". Based on that the cost of the system obstructs its implementation in the city where people avoid using the system into their facades because they can't afford it. As the landscape architect Rasha Samawi claimed: "Our design team could convince many clients to apply LWS into their buildings, people love to be surrounded with plants, but during construction the clients eliminated the system due to its expensive cost".

The cost of LWS is six folds the cost of conventional cladding materials such as stone, whereas, the minimum cost of LWS is 350 Euro per square meter (Perini and Ottele, 2014), and the average cost of stone in Amman is 50 Euro per square meter. Therefore, according to all the participants the cost of LWS is unaffordable for the majority of people in Amman.

The architect Ammar Khammash stated: "The cost should be almost as same as the conventional materials, or at least more expensive by 10percent-15percent in order to be accepted in Amman, but this cost of living wall is a disaster for the system in the city". The architect Emad Dabbas stated: "The cost of the system is the biggest challenge, it is so expensive, and even if we reduce it by 50percent, it will remain expensive and people can't afford it".

Based on that, the cost of LWS prevent it to be widely acknowledged and applied in Amman, because the majority of people can't afford it, which makes it exclusive only for rich people and big companies who can afford the cost of it, and that's why many people consider LWS as fantasy material. Moreover, the previous perspective has been supported by another participant. However, this time from LWS firm based on Istanbul, as Silvanus company representatives stated: "Most of our clients are rich people, big companies and municipalities who are capable financially to afford the cost of the system, because it is very expensive".

The cost of LWS plays an important role of its dissemination and implementation (Perini and Ottele, 2014). It is very expensive cladding materials comparing with the conventional and traditional materials. So, the cost is one the main disadvantages of LWS that hinders its installation (Mir, 2011).

Another challenge regarding the cost issue, is the availability of LWS in Amman market, as the landscape architect Murad Abeda stated: “There is no local materials yet that people are aware of it to use it in the system, which of course increase the cost…. because importing the materials form outside the country is an obstacle”. As it is mentioned in the previous sections, there is no local specialized company that install the system, therefore, people and architects rather contact an overseas suppliers or contractors import the components of the system. Both ways increase the cost of system and makes it more expensive which is an obstacle. More detailed view was provided by the architect Jeries Hiremat about the effect of foreigner suppliers on the cost, who claimed:

“when we designed the first green building in Amman, we wanted to integrate LWS into 400 m2 façade. but we couldn’t find a local supplier, so we had to contact with a foreigner supplier overseas, the cost they asked for installing the system was almost 1 million dollars! And that’s is extremely expensive and definitely the client rejected it”.

The above quote, shows the negative impact resulted by the absence of local materials and manufacturer, which leads to an extreme rising in prices that is unaffordable for anyone even those who are capable financially and definitely that’s a serious obstacle for the system in Amman.

LWS requires a constant supply of water and intensive maintenance, as the project manager Miqdad Rababa stated that: “The initial cost of system with the cost of water and electricity bills makes the system not efficient, cost is a real challenge here”. So, beside the initial cost of the system there is an operational cost which makes the system cost more money, therefore, more economical challenges for LWS in a city suffers from its economic challenges. However, based on the literature review, the energy required to operate LWS’s irrigation system is not too much and can be affordable by the public, but the main issue with the operational cost is the maintenance cost (Urrestarazu et al, 2016).

Regarding the maintenance cost, GAM’s representatives stated: “Even if the cost of LWS is equally as same as conventional materials, but still there is the maintenance cost for the system, where conventional materials don’t have a maintenance cost. That is a real challenge”. The most used cladding material in Amman is the natural stone, even if it is more expensive than other cladding materials people apply it to their building’s facades,

due to a general belief that stone materials stay forever and won't cost them any amount of money for maintenance. So, based on this mentality and culture, it is an obstacle for LWS which requires constant payments for its operational process specially the maintenance. Moreover, the maintenance cost seems to be one of the main factors that limits the implementation of LWS on a wider scale (Giordano et al, 2017).

Opportunities

The way to facilitate the implementation of LWS into building's skins despite of its expensive cost, is through economical benefits that the system can provide, as Jordan green buildings council representatives stated: "we should link the implementation of LWS with economical benefits (business case) in order to convince people". The opportunity here is to approve to the people that LWS is an investment for them and their buildings, as the project manager Meqdad Rababa claimed: " People don't care about the environmental advantages of the system such as filtering the air, what people care about is the investment of the system, for example: reducing the electricity bills, the system must have an investment in order to be accepted with these prices".

Moreover, it has been approved by many studies that LWS is an efficient investment, mainly through two main ways. Firstly, LWS improve the aesthetic value of the building, which makes the building recognized. Therefore, increase the property values by raising sale prices and rentals. Secondly, LWS reduce energy consumption for cooling and heating in summer and winter through improving the thermal insulation of the building. Therefore, reduce energy bills (Hopkins et al, 2010; Urrestarazu et al, 2016). According to the project management Migdad Rababa, buildings in Jordan consumes 61percent of the total electricity consumption of the kingdom which is a huge percentage. Furthermore, most of the buildings in the country are not thermally insulated and that's why buildings consume large amount of electricity for air-conditioning during summer. However, LWS is very effective insulation layer when integrated into building's walls which are not thermally insulated, whereas it is approved by a scientific experiment that LWS can reduce energy demand for cooling in a Mediterranean climate up to 65percent when it is integrated to non-insulated south-facing façade (Mazzali et al, 2012).

5.4 TECHNICAL OBSTACLES

5.4.1 Maintenance

The term “Maintenance” is not likable for the architects and people of Amman. Whereas, it is considered by all the participants in Amman as the biggest challenge faces LWS specially in a city like Amman. The architect Ammar Khammash stated: “people and architects in Amman want a free-headache and free-maintenance methods and experience”.

Based on that, people of Amman don’t like and avoid any kind of materials that require maintenance. Moreover, they don’t like to spend time and efforts on maintenance specially in buildings sector, because they understand maintenance as something negative that causes problems and headaches, so it is part of people mentality and culture and that’s why maintenance is considered as one of the biggest challenges faces LWS in Amman.

The LWS contractor Mohammed Abu Rouza claimed: “In this country I don’t think the LWS has a future to be a common cladding material, because we don’t have the culture of maintenance, and this system requires a lot of maintenance, people want a free maintenance system something like plastic green wall”.

The quote above illustrates, how people mentality and culture regarding the maintenance hinders the existing of LWS in the city. Moreover, many LWS projects has been replaced with artificial green walls because these artificial walls don’t require maintenance so that’s why people apply it instead of LWS which requires intensive care and maintenance. Furthermore, the landscape architect Hamzeh Mahasneh stated: “Moss walls are well known in Amman”. Moss walls are kind of green walls that don’t require any maintenance (Riley, 2018), and they are more acknowledged and applied in Amman than LWS, because of the maintenance. So, it is obvious how maintenance plays an important role in the application of LWS in the city and it hinders its existing.

The previous perspective was also supported by the landscape architect Belal Bakir, who claimed: “Maintenance is a real challenge, so that’s why people applied artificial plants in order to avoid the intensive maintenance, even if the cost of these artificial plants is more expensive”. Based on that, people in Amman consider maintenance as a real

obstacle so they pay more for other methods and materials in order to avoid it and that is illustrated by their choices for the conventional cladding materials where they prefer stone over paints, despite the fact that the cost of stone cladding is more expensive than the cost of paints cladding, but according to people opinion, stone cladding don't require maintenance and last forever, therefore, they don't have to be worry about its longevity and they don't have to spend time, efforts and money on maintaining their façades. Moreover, the architect Wael Al-Masri stated: "We look to architecture as permanence product or material, LWS is not a sustain material, so I believe it won't be an alternative cladding material like stone". people understand architecture in Amman as a permeance practice and elements that don't require any maintenance and can last for decades and centuries. This perception of architecture is a real obstacle for LWS which requires intensive maintenance and also has a limited lifespan.

The chief designer of 'Green over Grey' a Canadian LWS firm, Mike Weinmaster stated: "If people have an issue with looking after plants then they perhaps should not have them". Based on the previous analysis and discussions, people in Amman have an issue with maintenance. So, it is obvious maintenance is the biggest challenge faces LWS in the city of Amman. Furthermore, in building sector still there is a great hesitation among architects, contractors and clients to apply LWS, mainly due to the extensive maintenance the system requires which a main disadvantage (Ottele, 2011). However, reducing the maintenance to the minimum seems to be the only opportunity for the system regarding its intensive maintenance. the landscape architect Yazan Kamel Mahadeen stated: "Maintenance also is another main challenge. But it is also depending on the plant selections, because some plants don't require a lot of maintenance specially the native plants which grow in Amman by its self without any maintenance". based on that, the key success to reduce the maintenance is by carful and good plants selection. Furthermore, LWS is based on self-automated irrigation system that provides water and nutrients automatically to the plants that ensure the longevity of plants which minimize the maintenance to the minimum (Tzortzi et al, 2018).

5.4.2 Water

Water is a critical issue in Jordan where the country is the third driest country in the world, water resources are limited in the city of Amman. Therefore, the amount of water LWS requires is a debatable challenge among the participants in Amman. Many participants believe that water is not a challenge for LWS, whereas the amount of water that LWS consumes is not too much and can be affordable by all the citizens in Amman. On the other hand, other participants claimed that water sacristy in Jordan is a real challenge and obstacle for any technology based on water for its survival, therefore, water is a challenge for LWS in Amman city.

The project manager Meqdad Rababa stated: “We have problem with water, where the city of Amman doesn’t receive water continuously (daily), people receive water once or twice a week, I believe irrigating LWS with water will not be a priority for people due to water scarcity issue”.

Also the Dr.Maha Al-Zu’bi stated: “Water is a challenge! 3-5 L/1sqm per day is critical amount in Amman, the city is poor with water resources it has only two water sources, water consumption is priority for human usage and manufacturing not for green areas and vertical gardens”.

So, due to water scarcity in Jordan, people in Amman have a limited water supplies, where they receive a limited amount of water twice a week or once a week in some areas in the city. So, because of the limited water available people have to consume water wisely, therefore, they prioritize their water consumptions for essential needs and usages. However, people consider landscaping which includes LWS isn’t a priority for their water consumptions and that’s why many participants consider water is an obstacle for LWS in Amman. The landscape architect Hamzeh Mahasneh stated: “We have a problem with water, we are poor with water, people are avoiding green areas in their houses in order to save water”. Based on that, saving water for priority activities which excludes irrigating green areas is a real challenge for LWS in Amman.

Additionally, the architect Murad Kalaldeh claimed that: “Water is our biggest problem in this country we are so poor with water, if the situation continues like this without any

solutions to bring the water to the city, I believe the government will establish rules that limit our usage of water, and that of course an obstacle for LWS which is based on water".

On contrary, other participants in Amman opposed the previous perspective, where they believe water scarcity in the country is not an obstacle for LWS. Because the amount of water the system requires is relatively few, which is not a burden for people's water storage, therefore, people are able to irrigate the system. The landscape architect Belal Bakir claimed: "The amount of water the system needs is not too much. So, water scarcity is not a problem for the system".

GAM's representatives stated: "water sacristy is not a challenge for living walls, 3-5 L/1sqm is not too much water, we use much more than this amount to irrigate one tree". Another aspect of LWS regarding the water issue is that LWS consumes less water than the conventional plants irrigation, because it is based on hydroponic culture which makes it a very efficient technology regarding water consumptions (Hopkins et al, 2010). According to the landscape architect Hamzeh Mahasneh who clamied: "In case of LWS since we use an artificial media, we consume less water than the traditional planting, whereas natural soil absorbs more water than the artificial one and by the use of hydroponic system for irrigation we consume less water. So, water is not a problem for LWS". Based on that, LWS consumes few amounts of water which is an opportunity for the system to be wildly applied in a city like Amman, which has a limited water resources.

Jordan green building council's (JGBC) representatives stated: "3-5 L/1sqm per day is a critical amount of water, water is a real obstacle in a city like Amman, but we can reduce that by using native species that don't require a lot of water". Also, the landscape architect Yazan Kamil Mahadin stated: "Water is not a challenge at all, yes Jordan face water scarcity issue but it is not an issue for LWS, because we can manage the water usage for this system".

Based on that, another way to reduce and manage the irrigation for LWS is through the right plants selection, where Amman has a plenty of native plant species that require a little amount of water to survive. Therefore, by applying these native plants into LWS, the irrigation required for the system will be reduced. So, proper plants selection is an efficient way to deal with water scarcity in Amman. This perspective was supported by

Dr.Maha Al-Zu'bi who stated: " Some of the solution for water scarcity is the use of a native plants or other plants that don't require a large amount of water". Furthermore, the literature review support with the previous perspective, as Urrestarazu et al (2010) stated: "Good species selection is a key design parameter to minimize water requirements".

Another way to minimize water requirements is through irrigating LWS by the rainwaters and grey water. Dr.Maha Al-Zu'bi claimed that: "A solution for water scarcity in the city is by creating water tanks that collect rainwater, these collected water can be used for landscape and also irrigating the green walls". The average annual rainfall in Amman is 480 mm, rain falls during winter period which starts from November till April, the summer period extends from May to late September where it is known as a rainless period. The average annual harvested rainwater through building roof surface in Amman is 0.48 m^3/m^2. For example, in a 300 m^2 building's roof surface, the average annual collected rainwater is about 144 m^3 (Al-Houri et al, 2014; Abu-Zreig et al, 2012).

The reuse of grey water is another promising way to reduce water demand on the main water supply as the architect Murad Kaladeh stated: "The reuse of grey water is a perfect solution, in instead of waste this water we can use them to irrigate the plants".

Based on the above quotes, it can be argued that the reuse of rainfalls and grey water for irrigating LWS is a good way to reduce the demand of the main water supply and cut-off the cost of water bills. However, constructing water storage tanks and the treatment process of grey water are costly which may increase the total cost of LWS installation (Urrestarazu, 2016).

6 . CONCLUSION

Living wall systems (LWS) are becoming a trend in many places around the world, many cities are involving these systems into their regulations and policies, due to their capability and ability to help addressing some of the main environmental issues such as: climate change. Unfortunately, LWS are not acknowledged and widely applied within the architectural practices in Amman the capital city of the Hashemite Kingdom of Jordan. Based on this fact, this research was developed, aiming to define the barriers that hamper the implementation of LWS in Amman. Another aim is to highlight the opportunities of these systems to be a common cladding material in Amman construction industry.

The findings of this dissertation were carried out through a discussion between a secondary data that is derived from books, periodicals and other publications related to LWS, with analyzed primary data that is gathered through open-ended interviews. The interviews were made with different specialists in Amman within the fields of architecture, landscape architecture, botany, environment and decision making; in addition to LWS specialized firms that are located in Istanbul, Antalya, New York and Toronto.

The thesis has presented four main challenges that hamper the existence of LWS in Amman. These four challenges are represented by: cultural obstacles, lack of encouragement, cost and technical obstacles. Under each of these challenges the thesis has shown some of the solutions and opportunities that help to face these challenges and pave the way for the existing of LWS in the city. Table (6.1) summaries all the presented challenges and opportunities.

Table 6.1: Summary

Challenges	Opportunities
Culture and mentality	Raising awareness
Lack of knowledge	Raising knowledge
Lack of awareness	Governmental support
Lack of encouragement	International organizations support
Lack of policies and rules	Policies and regulations
Lack of incentives	Pilot projects

Lack of coordination Installation cost Maintenance cost Technical obstacles Maintenance Water scarcity	Incentives Investment Water efficiency Native plants Reuse of rain water Recycling grey water

Cultural obstacles are represented by the lack of knowledge and awareness of LWS among clients, architects and decision makers. This absence of knowledge and awareness is considered as the main challenge which prevent the integration of LWS into architects' works. The same point of view is also preventing these systems to be included into regulations and policies that encourage its implementation. In addition, people's mentality and culture is another considered obstacle, where it is difficult to get people to accept new materials, since there are adhere to their traditional materials. However, educational efforts, such as seminars and lectures can help to increase the level of knowledge and awareness of LWS and their benefits among different players.

The absence of regulations, polices and incentive programs is the main reason for the lack of encouragement of these systems in the city. This is considered as one of the main challenges LWS face in Amman. Furthermore, the lack of coordination between different institutions from the private and public sector is another obstacle that negatively affect the developing of regulations and incentives that support the applications of LWS. However, the thesis has shown different examples from different cities around the world that succeeded to increase the implementation of LWS through regulations and incentive programs. Therefore, including LWS into the construction regulations and guidelines is a great encouragement for these systems. Pressure and support by international organizations who can motivate the government in Amman to adopt these systems into its policies would be very helpful.

LWS is a new technology; this makes its cost extremely expensive compared with other conventional cladding materials. Therefore, the cost is considered as a big challenge that these systems face especially in Amman due to economic difficulties the city is witnessing. Furthermore, the operational cost, especially the maintenance cost, increases

the total cost of LWS which makes it unaffordable. Moreover, the absence of local materials and local specialized firms, negatively affect the prices of LWS. However, providing incentives is an opportunity which helps to reduce the cost of the system, but more importantly is the investment side that LWS can provide through increasing the property value and decreasing the energy bills. Therefore, the investment of LWS is considered as a great opportunity that pave the way for the implementation of LWS despite of its high installation cost.

Maintenance and water that the system continuously requires, were presented as the main technical obstacles LWS face in Amman. Maintenance seems to be the biggest challenge among other challenges that LWS face in Amman. It appeared that maintenance is not part of the culture and practices of the people in Amman especially when it comes to buildings. Moreover, there is a wide belief among the people in Amman that architecture is immortal and doesn't need maintenance. Therefore, any new materials that require continuous maintenance like LWS will be rejected and avoided by the people. However, LWS is operated by an automated irrigation system that provides plants with their needs of water and nutrients automatically and that's minimize the maintenance to the minimum. Any kind of effort that helps to reduce the maintenance is great potential for the system in Amman.

The thesis has shown that the amount of water the system requires is the most controversial issue. Mainly two opposing perspectives were presented, the first one considered the water needed for the system is a real challenge due to the water scarcity issue in Amman. On the contrary, based on the second perspective, it seems that water scarcity is not a challenge for LWS, because it is based on hydroponic culture which consume less water than the conventional planting methods. Moreover, the use of native plants which don't need a lot of water is a great opportunity to overcome the water scarcity. The use of rain water and the reuse of grey water are other great potentials to reduce water consumptions on irrigation.

Though presenting the main challenges and opportunities within a one piece of academic work, this master thesis achieved a better understanding of LWS integration into the architectural practices and buildings sector in Amman. Moreover, the findings of the

research could be a helpful guideline for further researches and practical implementation. More importantly, the thesis shows that water scarcity in the city can be an opportunity not a challenge for LWS, due to their efficiency regarding water consumptions.

The following is a number of recommendations for further researches that can help to pave the way for the applications of LWS and improve their implementation in the future:

a. A research on native plant species that can survive in Amman with minimum needs of water and maintenance.
b. A review on local materials in Amman that can be part of LWS components.
c. More studies of the cost benefit analysis of LWS within the data in Amman.
d. Scientific experiments for the influence of LWS on energy consumptions.
e. More studies about irrigating LWS by the use of rain water and grey water.

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