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Water, Energy, and Rooftops: Integrating Green Roof Systems into Building Policies in the Arab Region

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Abstract

Recent research claim that adopting green roof systems in building sectors in the Arab region is becoming necessary because of the current environmental, social, and economical challenges. Some Arab countries have already developed green building rating systems and recognized the importance of green roofs; however, they still do not fully benefit from such systems owing to limited supporting policies and financial incentives. The purpose of this article is to contribute to a better understanding of the potential role of green roof systems in effective planning and moving towards sustainable urban development in the Arab region. We argue that integrating green roof systems within governmental policies and green building strategies would potentially help in saving energy, enhancing water management, and coping with climate change. This paper presents a conceptual framework to help governments in the Arab region to adopt green roofs in their environmental policies. To present this framework; first, we studied the current international policies that adopt green roof systems and practices, then proposed a conceptual framework for adopting green roof systems in the Arab region. Second, we have chosen Cairo, Egypt, and Amman, Jordan from the Arab region to demonstrate the applicability of this framework at city level while considering the national and local context. This demonstration provides a novel perspective for the benefits of green roof systems in energy savings and water management in the Arab region.

Keywords: Green Roof Systems, Arab Region, Government policy, Cairo, Egypt, Amman, Jordan

1. Introduction

High population growth and rapid urbanization are seen as the most prominent challenges for urban planners and policy makers in the Arab region (Mirkin, 2010; UNDP, 2009, 2011). Over 55% of the Arab population is now living in urban areas, and it is expected to grow to 67% by 2050 (UN-HABITAT, 2012). Most Arab countries' built environment is confronted by climate change and the high demand on natural resources, especially energy and water (Verner, 2012). In addition to its scarcity in most Arab countries, water has been considerably mismanaged in urban centers as a result of uncontrolled urban growth (UNDP, 2013). Further, Arab cities experience tremendous inefficiencies in energy consumption (Al-Asad & Emtaireh, 2011). The issues of energy and water conservation in the region has gained a massive public interest due to their direct impact on the budget of both the government and individuals (UN-ESCWA, 2011). Further, most agriculture lands in and surrounding Arab cities have been destroyed (e.g., Cairo, Amman, Beirut, and Damascus). This has resulted in leaving these cities food insecure, struggling to manage storm water, and lacking public green areas, which serve as the city's breathing space and essential places for relaxation and leisure for its inhabitants (Arabnews, 2014; Tawk & Hamadeh, 2014).

Building sector is one of the fastest growing sectors in the Arab region to cope with high population growth and rapid urbanization (LAS, 2005; UNDP, 2013). Building sector impacts the economic and environmental performance of the cities and social wellbeing of their residents (UNEP, 2011). For example, the building and construction sector accounts for 6–12 % of the gross domestic product (GDP) of Arab countries and employs 9–15 % of the domestic labor forces (Al-Asad & Emtaireh, 2011). On the other hand, the building and construction sector presents major environmental and social challenges in the Arab region (UNEP, 2009, 2011, 2012). For example, buildings in Arab countries account for an average of 35% of all energy consumption (MED-ENEC, 2006), and contribute to 35–45% of all CO_2 emissions (AFED, 2012). Figure 1 shows the share of the building sector in the final energy consumption in selected Arab countries.

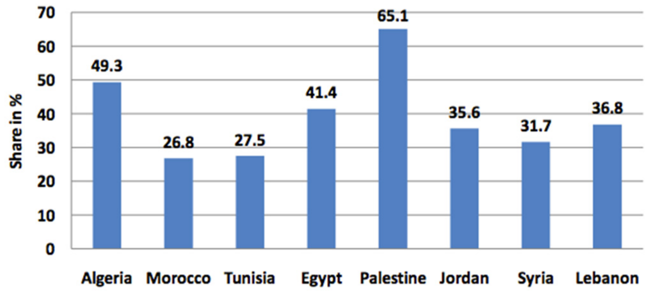

Figure 1. Share of the Building Sector in the Final Energy Consumption in Selected Arab Countries (MED-ENEC, 2006)

Yet, in spite of the development of the building and housing sector in Arab countries, the environmental and social dimensions of this industry has not received attention from governments nor has it been integrated with other governmental sectors (AFED, 2011; Al-Asad & Emtaireh, 2011). In addition, the building and housing sector in the Arab region is governed by several laws, these laws are mostly enacted by multiple actors and authorities with different roles. In many cases, influences from multiple laws and actors create unavoidable obstacles for effective implementation. These obstacles are mostly associated with centralized governance, incoherent policies, existence of various laws governing and organizing urbanization, institutional overlapping and lack of coordination, limited resources and skills, and regulations incompatible with the social, climatic, and environmental conditions (LAS, 2005; Verner, 2012). Conventional planning, design, construction and operations processes often fail to recognize that buildings are part of larger, complex systems (Travis 2014). Scholars argued that the building sector needs to be integrated with other governmental sectors in order to contribute better to sustainable built environment (Al-Asad & Emtaireh, 2011; LAS, 2005).

In the face of a changing climate and the increasing number of issues stemming from economic development and human urbanization, the needs for more efficient environmentally friendly buildings and green infrastructure are becoming increasingly acknowledged around the world, and implementation rates have begun to rise (Hoornweg, Freire, & Lee, 2011; Theodosiou, 2009; UNEP, 2009, 2011). One of the green strategies is adopting green roof systems in building sectors in order to reduce the impact of the rapid urbanization (IMAP, 2013; Theodosiou, 2009). The role of rooftops has historically been a peripheral consideration in the development of urban infrastructure and they are currently an untapped resource in urban areas. Therefore, development policies, incentives, and public support are crucial to explore their full potential (BayLocalize, 2007).

Roofs are important architectural and structural elements for buildings. They form the style of architecture, shape the skyline of the city, and protect the upper floors from rain and the heat of the sun. Moreover, they resist the wind forces and carry different loads for users' activities and building service equipment. Roofs are important factors in determining the flow of energy from and to buildings (Oberndorfer et al., 2007a). They also help in dealing with rainwater in the urban environment; they can keep, guide, or waste any precipitation that falls on a building.

The rooftop, the upper layer of a roof facing the sky, has been found to be intricately tied to the sustainability of a building and hence the built environment as a whole. The materials used in rooftops play a significant role in the heat island effect through their texture and color. The materials with high solar reflectance, such as white, smooth rooftops, reflect sun's light and heat, help in cooling the building, and save energy in a warmer climate (Ascione et al. 2013). On the contrary, materials with low solar reflectance, such as dark, rough rooftops, could help in heating buildings and saving energy in a cold climate. Having green roofs (roofs with a vegetated surface and substrate) provide ecosystem services in urban areas, it improves storm-water management, regulates building temperature, reduces urban heat-island effect, and increases urban wildlife habitat (Oberndorfer et al., 2007b).

Roof gardens, the historical name of current modern green roofs, have ancient roots. The first roof gardens appearing in history were the Hanging Gardens of Babylon (also known as Gardens of Semiramis), built about 575 BC (see Figure 2). The modern green roof concept started at the beginning of the 20th century in Germany, where vegetation was installed on roofs to mitigate the damaging physical effects of solar radiation on the roof structure. Early green roofs were also employed as fire-retardant structures. There are now several competing types of extensive green-roof systems, which provide similar functions but are composed of different materials (Oberndorfer et al., 2007).

Figure 2. Hanging Gardens of Babylon (New World Encyclopaedia)

In modern architectural movements, a number of concepts relevant to using various roof systems have been developed, e.g., green roof (Rashid, Ahmed, & Khan, 2010; Specht et al., 2014), urban farming (Hui & SCM, 2011), living roof (Roehr & Fassman-Beck, 2015), vegetated roof (Berndtsson, 2010; Getter & Rowe, 2006; Rahman, 2011), eco-roof (Getter & Rowe, 2006), ZFarming (Specht et al., 2014), and nature roof (Fioretti, Palla, Lanza, & Principi, 2010).

Simply, all these concepts refer to a roof that has soil or planting media that hold various types of vegetation. While each of these concepts is translated differently depending on the context within which it is being used, the overarching goal is to achieve sustainable, green, and living open space (Getter & Rowe, 2006; greenroofs.com, 2014; Köehler, 2005; Meaton & Alnsour, 2012; Ngan, 2004; Rahman, 2011; Roehr & Fassman-Beck, 2015; Specht et al., 2014; Zarandi, Pakari, & Zaimi, 2011).

In the last 40 years, green or vegetated roofs were widely accepted as one of the preferred solutions for sustainable built environment. According to Oberndorfer et al. (2007a), the components of green roofs can improve the performance of buildings on its local ecosystems and can reduce buildings' energy consumption (Sonne, 2006). A green roof not only adds esthetic value to the buildings, but also enhances the thermal performance of buildings and minimizes heat transfer, which eventually helps in controlling the indoor temperature (Goussous, Siam, & Alzoubi, 2015). Green roofs can also mitigate storm-water runoff from building surfaces by collecting and retaining precipitation, thereby reducing the volume of flow into storm-water infrastructure and urban waterways. Other potential benefits include green-space amenity, habitat for wildlife, air-quality improvement, and reduction of the urban heat-island effect (Getter & Rowe, 2006). Green-roof technology is now widely accepted, and policymakers and the public understand its benefits, which have been communicated in the media for years. Although green roofs are initially more expensive to construct than conventional roofs, they can be more economical over the life span of the roof because of the energy saved and the longevity of roof membranes (Porsche & Köhler, 2003).

Worldwide green roofs have been integrated into various green building guidelines to promote the use of this technology. For example, owing to their water retention capacity, their ability to provide thermal insulation in cold climates and to protect from overheating due to the high solar exposure of roofs in warm climates, and their ability to reduce urban heat island effects (Theodosiou, 2009), green roofs have been acknowledged in such performance-based regulations as Leadership of Energy and Environment Design (LEED), and their contribution may count for up to 15 credits under the LEED rating system (Kula, 2005).

The underlying purpose of this paper is to offer practical and attainable solutions for Arab policy-makers in working towards sustainable urban development. Specifically, it will assist Arab municipalities in incorporating green roofs into their official urban plans, policies, and operating procedures. The findings provide a comprehensive perspective on challenges and opportunities facing green roof applicability at the national and city levels in the Arab region.

2. Method

In this research, we supported our argument through case studies based on secondary data analysis to enrich the available green roof system assessment approaches, help to explain what would hinder or support accommodating green roofs practices in the Arab cities, and provide a robust means and framework to guide policymakers to design integrated green roof policy in order to respond to urban environment challenges. The following research strategies were applied as illustrated in Figure 3:

1) **Input (data collection):** a comprehensive literature review was conducted for green roofs' definitions, characteristics, benefits, and contribution to sustainable urban development. Additionally, green-roof-preceding documents related to the Arab region context — legal, regulatory, challenges and opportunities, green building, green roof policies, and relevant incentives — were also reviewed. Further, the critical factors and interventions that are connected to green roof design in hot arid climates were investigated. Additionally, successful green building policies were analyzed to provide a critical understanding of current policies, incentives, and international experiences. Green roof policies in six countries were explored, the countries included Canada, USA, Germany, Demark, Singapore, and Australia, they represent different climatic regions. The review highlighted research, guiding policy frameworks, and examples of successful case studies. This review resulted in multifaceted summary and analysis of the relevant available research and non-research literature.

2) **Data Processing:** A single method or source of data can never adequately shed light on a situation; however, combining multiple sources of data can help facilitate deeper understanding and overcome qualitative research weaknesses and biases (Koch, 1994; Cohen & Manion, 2000; Creswell & Miller 2000; Shenton, 2004). This step critically compared, integrated, and analyzed the information derived from the literature review (theoretical and policy literature) and then cross-checked the information with that which was obtained from the various case studies (applied policy). It produces a richer context, helps examine evidence from researched sources, overcomes bias, and builds a coherent justification for the study recommendations.

3) **Outputs:** based on the literature review (data input and processing), we developed a practical green roof conceptual policy framework to identify options for improvement and to systematically develop solutions may be used to support Arab policy-makers to handle the challenges of green roof policy development in the Arab region. The proposed policy framework consists of six phases to guide and help the local Arab governments in developing green roof policies taking into account the vertical and horizontal policy integration.

4) **Applicability:** Cairo, Egypt, and Amman, Jordan, were selected to explore their green roof situation, and demonstrate the applicability of the proposed integrated policy framework at a city level while considering the national and local context.

2.1 Results Validation

The green roof conceptual policy framework design was based on longstanding municipalities' experiences, which create foundation and source of best practices and knowledge. Further, both researchers are originally from the region (Jordan and Egypt) and are familiar with the region's local context, this helped the researchers to identify the local challenges in light of the international attempts, this reflection ultimately helped them to propose a policy framework that could be a starting point for adopting green roofs in the Arab region. In addition, the proposed framework was checked through "peer debriefing", informally presented in front of other scholars who are familiar with the research topic, which provide an excellent opportunity to discuss and receive feedback. According to Jabareen (2009, page 55), "A theoretical framework representing a multidisciplinary phenomenon will always be dynamic and may be revised according to new insights, comments, literature, and so on" (Jabareen, 2009). Despite the limited preceding literature related to green roof in the Arab region, the applied method (research strategies of data collection and analysis) provides a clear understanding and suggests recommendations for Arab policy-makers.

3. Contribution of Green Roofs to Sustainable Urban Development

Building and housing sector has an important role in the sustainability of the economy, society, environment, and culture (UNEP, 2009, 2012). Building and housing sector is intricately tied to dimensions such as environment through urban sprawl, resource consumption (material, energy, water, etc.), infrastructure requirements (transport, energy, sewer system, and water supply), and people's sense of the value of their neighborhoods (Dodman, McGranahan, & Dalal-Clayton, 2013). Therefore, sustainable urban development requires integration and coordination, including land-use issues, food security, employment creation, transportation infrastructure development, biodiversity conservation, water conservation, renewable energy sourcing, waste and recycling management, and the provision of education, health care, and housing (UN-DESA, 2013).

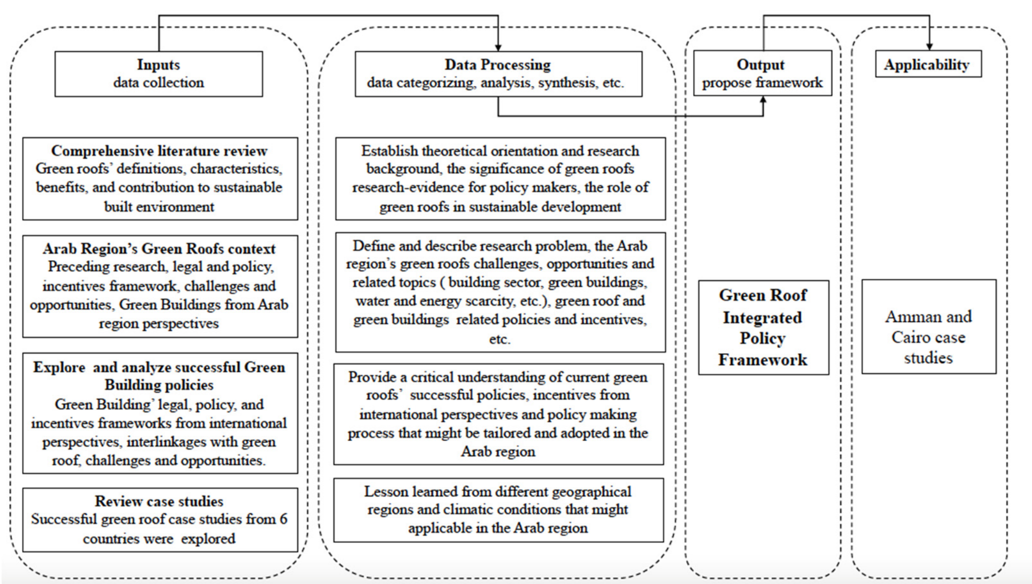

Figure 3. Method landscape

Researchers claim that green roof systems are intricately tied to the goals of the sustainable urban development, including the economic, social, and environmental dimensions (Berndtsson, 2010; Hui & SCM, 2011; Roehr & Fassman-Beck, 2015; Specht et al., 2014; Stewart, 2009; Whitman, 2013; Zarandi et al., 2011). Implementing green roof systems maximizes the synergies between the sustainable development principles, such as socio-environment, environment-economy, and socio-economy resulted in better air quality, social cohesion, high aesthetic values, recreational opportunities for building occupants, and better storm-water management. Figure 4 shows how green roof systems contribute directly and indirectly to the sustainable urban development. Therefore, green roof policies, approaches, and incentives must be integrated vertically and horizontally with related-sectors' policies and should be advocated at the local level to support sustainable urban development.

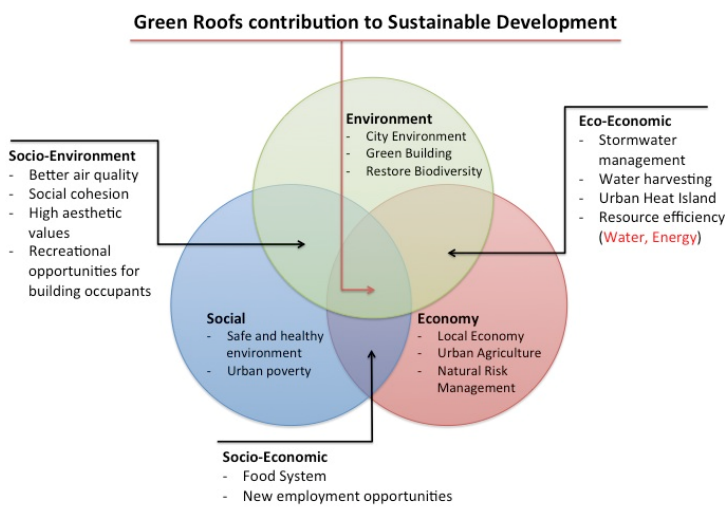

Figure 4. Green Roofs' Benefits in the Context of Sustainable Development

Table 1. Contributions of Green Roofs to Sustainable Development Goals

Sustainable Development Goals	Green Roof Contributions
Goal 1: End poverty in all its forms everywhere	- Creates opportunities for low-income people to find employment through, construction, installation, or maintenance (Kingma, 2012) - The money spent on produce grown locally and sold in farmers' markets stays in the community, raising incomes and creating jobs (Kisner, 2008; Zeeuw, Veenhuizen, & Dubbeling, 2011)
Goal 2: End hunger, achieve food security, and improved nutrition and promote sustainable agriculture	- A supply of homegrown food, and especially fresh nutritious vegetables, makes a difference in the lives of the urban poor through improved nutrition (Kisner, 2008; Whitman, 2013)
Goal 3: Ensure healthy lives and promote well-being for all at all stages	- Contributes to the greening of cities, curbs air pollution, increases humidity, and lowers temperatures (Goussous, Siam, & Alzoubi, 2014; Lehmann, 2013; Specht et al., 2014; Zarandi et al., 2011)
Goal 4: Achieve gender equality and empower all women and girls	- Indirectly empowers women, the predominant urban producers, to gain access to income and control over household resources and decision-making (Kisner, 2008; Rashid et al., 2010)
Goal 5: Ensure availability and sustainable management of water and sanitation for all	- Green roofs' growing media retain rainwater and, together with plants, return a portion of this water to the atmosphere through evaporation and transpiration (evapotranspiration) - Storm water that does leave the green roof is delayed and reduced in volume; it is cleaner than runoff from a conventional roof - Retention and delay of runoff eases stress on storm water infrastructure and sewers (Fioretti et al., 2010; Köehler, 2005)
Goal 6: Ensure access to affordable, reliable, sustainable, and modern energy for all	- Reduces the heat influx through the roof; less energy for cooling or heating can lead to significant cost savings - In summer, a green roof protects the building from direct solar heat; however, in winter, it minimizes heat loss through added insulation on the roof (Fioretti et al., 2010; Goussous et al., 2014)
Goal 6: Ensure access to affordable, reliable, sustainable, and modern energy for all	- Reduces the heat influx through the roof; less energy for cooling or heating can lead to significant cost savings - In summer, a green roof protects the building from direct solar heat; however, in winter, it minimizes heat loss through added insulation on the roof (Fioretti et al., 2010; Goussous et al., 2014)
Goal 9: Build resilient infrastructure, promote inclusive and sustainable industrialization, and foster innovation	- Planting vegetation in cities helps to cancel the concrete jungle effect wherein temperatures rise, polluted air is not filtered, and rainwater is not absorbed into the ground (Zeeuw et al., 2011)
Goal 11: Make cities and human settlement inclusive, safe, resilient, and sustainable	- Transforms the endless concrete of cities into productive green spaces (Hui & SCM, 2011; Kingma, 2012; Zarandi et al., 2011). - More economical and efficient over the life span of the roof because of the energy saved and the longevity of roof membranes (Porsche & Köhler, 2003). - Amenity space for day care, meetings, and recreation (Kingma, 2012). - Promotes sense of community (Kingma, 2012)
Goal 13: Take urgent action to combat climate change and its impacts	- Contributes to combating the urban heat island effect, increases energy efficiency (energy conservation translates into fewer greenhouse gas emissions), lowering temperatures and purifying the air city-dwellers breathe (Goussous et al., 2014; Hutchins, 2007; Lehmann, 2013; Rashid et al., 2010; Zarandi et al., 2011).
Goal 15: Protect, restore, and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss.	- Provides suitable habitat and refuge space for many birds and invertebrate species in urban areas and brings plants back into cities (Buholzer & Wark, 2006; Foster, Lowe, & Winkelman, 2011; Getter & Rowe, 2006; Rashid et al., 2010; Zarandi et al., 2011)

In September 2015, world leaders pledged 17 sustainable development goals (SDGs), common actions and endeavors across the universal policy agenda. Scholars demonstrated that implementing green roof systems would directly and indirectly support the SDGs. Table 1 shows the positive aspects of green roofs and how they contribute to most of the SDGs to achieve environmental sustainability.

4. Green Roof Policies and Incentives

In this paper policy refers to government plans that influence the decisions made by governments. There are various types and forms of governmental policy: broad policy, which reflects government-wide directions; more specific policy developed for a particular sector (e.g., water, energy, etc.) or issue area (e.g., green roof); and operational policy, which may guide decisions on programs and projects selection (Farag, 2003; Rahman, 2011; White, 2012). Policy development is an integral part of the overall government planning process. Policies are used to provide clear guidance to national and municipal officials, the general public, and developers on how a city's vision for its future is to be implemented (Hodge, 2003). According to Farag (2003,1) "*with respect to the forms that government policy can take, it is reflected most typically in legislation, regulations, and programs. These are often referred to as policy instruments*".

Policies and incentives are the basic factors for successful technology development and deployment of the green roof systems and techniques (IMAP, 2013). Green roof policy and programs in each country are made unique to respond to the local environmental and urban challenges. However, its successful implementation is subject to climate conditions, available resources, capacities, and market readiness (Hui & SCM, 2011; Kula, 2005; Ngan, 2004). From the large body of literature published over the past 20 years, we deduce that green roof adoption is driven by various motivations, such as control storm-water runoff, reduce urban heat-island effect, lower building energy consumption, and food security. Accordingly, green roof policies were designed worldwide (nationally or locally) to target these benefits via specific legislation, regulations, and programs.

Currently, green infrastructure strategy is on the rise in Europe, North America, and Asia, and a number of large cities are beginning to incentivize their creation. For particular green roof systems, incentives were designed to encourage behaviors that increase the number of vegetative roofs (Ely & Pitman, 2014). Municipalities can directly and indirectly use various tools and incentives to encourage implementation of green roofs and stimulate the local market. These include, for example, stipulations in new land-use plans or green roof statutes for whole urban areas, education and champions, indirect financial incentives, direct financial subsidies, regulatory measures, performance rating systems, and building codes and regulations (IMAP, 2013). Table 2 illustrates some examples of green roof policy and incentives. Some are green-roof specific, others encompass all green building technologies implemented in various countries.

Table 2. Green Roof Policy and Incentive Examples.

Location	Method	Summary
USA – Federal	Federal Tax	According to the Energy Policy Act of 2005, federal tax credits of up to $1.80/ft^2 are available for green building projects that meet ASHRAE standards.
USA – Chicago	Floor Area Ratio (FAR) Bonus	The City of Chicago offers a FAR Bonus for developments including a green roof that covers 50%, or 2000 ft^2, of the roof area. The program is listed under the city code as "17-4-1015 Green Roofs".
Canada – Toronto	Eco-Roof Incentive Program	Offered by the City of Toronto to developers installing green and cool roofs on buildings not subject to the Green Roof By-law. Developers can receive $75/m^2 of green roof installed, up to $100,000.
	Green Roof By-law	Green roofs are required for all new development above 200 m^2. Coverage requirement ranges from 20% to 60% of the available roof space, and the law affects all new applications made after January 31, 2010.
France	Environmental Legislation	Rooftops on new buildings built in commercial zones in France must either be partially covered in rooftop gardens or solar panels.
Austria - Linz	Building Codes	Green roofs were introduced in 1985 as part of a development plan and are now included in Linz within local development plans.
Switzerland -Basel	The Planning Policy	The planning policy requires that all new flat roofs must be green roofs and therefore presents a very pro-active approach to encouraging green roof technology

A large body of research has shown that integrating green roof policies and incentives to wider strategic policies is significant for their adoption. For example, linking green roofs to key national strategies, such as water and energy efficiency, air pollution, community health, biodiversity, and climate change, would enhance planning and implementation and the overall outcomes of these policies (Achnitz, 2014; Ely & Pitman, 2014; Foster et al., 2011; Kingma, 2012; Perkins & Joyce, 2012; Roehr & Fassman-Beck, 2015; Specht et al., 2014).

5. Green Roof Existing Policies

Policy-makers can better determine which policies suit their needs (White, 2012). Longstanding municipalities' experiences create foundation and source of best practices and knowledge that can be adapted and tailored according to the need of the local green roof stakeholder. For example, European jurisdictions (especially Germany) have long used green roof technology for storm-water management, to reduce energy use in buildings, and to increase amenity space. More recently, it has been adopted in several countries, including USA, Canada, and Singapore. On the other hand, some Arab countries developed green building rating systems (e.g., Global Sustainability Assessment System (Qatar), Pearl Rating System (PBRS) (UAE), ARZ Building Rating System (Lebanon), and Egypt's Green Pyramid (GPRS)) in which they partially encourage having green roofs on green buildings, the momentum of green building as an effort towards urban sustainability is still very slow because green buildings are still individual attempts in most of the Arab region. However, a range of policy tools has been employed around the world to encourage inclusion of green roofs in new building designs and in retrofitting of existing ones. In order to illustrate the relevance of green roofs in the context the Arab region's climate, some interesting examples of green roof policies, projects and programs were selected from different countries/cities to be explored. Arab cities can learn from other cities about their motivations, successes and challenges in developing and implementing policies that support and encourage green roofs. Six cases were explored; Canada, USA, Germany, Denmark, Singapore, and Australia. These cases were selected because of the information available on the development, implementation of the green roof related policies and the result of applying them. Despite that the cases represent different climatic conditions, green roof types, benefits, policies, and incentives. Yet, all shared similar process and characteristics in developing the green roofs' policies. For instance, most case studies received policy-maker's support and leadership, conducted intensive research, engaged stakeholders, established green roofs' related technical or advisory committees, implemented demonstration projects and incentives mechanisms, aligned green roofs with other related sectors' objectives (water, energy, buildings, etc.), applied monitoring and evaluation mechanisms, and share the common goal of protecting the environment.

5.1 Canada - The City of Toronto

Since the mid-1990s the City of Toronto has had a number of high profile green roofs (greenroofs.com, 2014), it was one of the first cities in North America to have a green roof Bylaw to require and govern the construction of green roofs on new building designs and development.

The City of Toronto engaged in considerable research and stakeholders in developing the green roof strategy that led to the Bylaw. In 2004 the City commissioned a team of researchers to prepare a study on the potential environmental benefits of widespread implementation of green roofs to the city of Toronto, given the local context, environment and climate. The study indicated that widespread implementation of green roofs in Toronto would provide significant economic and environment benefits to the city (storm water management, heat island, and associated energy use for cooling). Accordingly, the City of Toronto in 2005 held a series of consultation workshops with green roof stakeholders to receive input on its proposed strategies to encourage green roofs. Based on stakeholders' workshops input and research findings, particularly the environmental benefits and costs of green roof technology studies, various options for encouraging green roofs implementation were developed. The development of the City's green roof strategy laid a foundation and solid policy framework for the development of the Green Roof Bylaw which was adopted by Toronto City Council in May 2009, under the authority of Section 108 of the City of Toronto Act (CityofToronto, 2010). The Bylaw was aligned with sustainable development related initiatives and approaches such as green buildings, energy conservation, green infrastructure, smart growth/sustainable urban design, and water conservations, etc. The Bylaw requires a green roof to be provided on certain new development over 2,000 m^2 and provides construction standard that all green roofs must be built in accordance with. Since the introduction of the by-law in 2009, 140 buildings and 16,000 m^2 of rooftops have planned for vegetation, with another 25,000 m^2 voluntarily provided in Toronto (Moulton, 2012). The Bylaw development process was challenged by limited awareness of the opportunities for green roofs, weak engagement of industrial and building sector in discussions on green infrastructure, absence of mechanisms to address cost barriers, and insufficient efforts to balance multiple land use policy and objectives. Therefore, the City of Toronto has supported the Bylaw related activities with technical guidelines, awareness workshops, stakeholders engagement, research and demonstration sites, and grants and subsidies.

5.2 United States of America - The City of Chicago

Since the 1990s, the City of Chicago's urban development plans has included promoting the use of vegetated roofs instead of conventional roofing materials. To lead by example, the City of Chicago constructed in 2000 a showcase green roof on its most prominent buildings, City Hall. The City of Chicago had the foresight to utilize green roofs to combat its urban heat island concerns and improve urban air quality. Further, the City officials realized that the multiple benefits of green roofs needed to be better understood under local conditions. Therefore, since 2002, the City continued its environmental leadership by implementing various research and pilot projects, opening the Chicago Center for Green technology, and launched grant programs (e.g., urban heat island grant program) (MWH, 2006).

Through Chicago's green permitting program, a green roof helps a project qualify for the expedited permitting process. Further, Chicago's stormwater management plan consider green roofs as one measure that can be used comply stormwater ordinances. Green roofs were integrated in Chicago Climate Action Plan as a potential solution (small-scale green infrastructure) to protect water quality through managing stormwater. The City of Chicago supported the green roofs implementation through various methods: codes or policies (e.g., land-use plan, green roof bylaw, zoning code, green factor, design regulations, etc.); density bonus; demonstration projects; education and information (e.g., seminars, conferences, green roofs tours, etc.) and research. These projects and initiatives supported the City's decision-making efforts regarding green roofs policy and practices (Lawlor, Currie, Doshi, & Wieditz, 2006).

5.3 Germany – The City of Hanover

Germany is the world leader in documenting the benefits of green roofs, advancing the technology and program, and developing policy. In the late 1970s, researchers started evaluating the ecological benefits of green roofs. The 1980s saw a number of municipal and state incentive programs aimed at bringing nature and green space back into the city. A number of green roof related policies were adopted (e.g., subsidizing 50% to 100% of the total costs) that encouraged a variety of urban initiatives, including green roofs. At least 24 German cities offered some type of urban greening subsidy by 1983. Further, Germany amended its Federal Building Code and Federal Nature Protection Law in the mid-1980s to include the Ecological Compensation and Replacement Measure.

The City of Hanover recognized that green roofs would make a sensible contribution to improving urban ecology based on green roofs research results and stakeholders' input. The green roofs advantages were laid out in the environment section of the urban development plan as early as 1987. The City of Hanover included exact green roof specifications in the city council's guidelines for green roofing in urban development plans, guidelines for handling rainwater in built up areas, and guidelines for environmental construction since 1994. Further, green roofs related incentives were provided such as reduced stormwater fee and financial incentives. Moreover, support was provided to conduct research and education programs, demonstration sites, and offer technical assistance (e.g., site visits, tours, technical manuals, websites, etc.) to constructors, investors and building owner (International Green Roof Association [IGRA], 2015b).

5.4 Denmark – The City of Copenhagen

Focusing on alternative ways to hander rain water motivated the City of Copenhagen to consider the green roofs in its 2008 Wastewater Plan. Various green roof research and pilot-projects were implemented, which provides a platform for further research on how to incorporate a bio diverse green roof on an existing roof and how to incorporate it into historic heritage buildings. Since 2009, based on research and stakeholder consultations the focus on green roofs intensified setting a goal for urban design with green roofs in the Climate Plan of the City of Copenhagen. Further, the green roofs have become integrated in different guidelines such as the guidelines for sustainability in constructions and civil works, which mandates green roofs for all the Municipality's buildings. Green roofs are also a part of the City's Strategy for Biodiversity, Climate Adaption Plan, A Greener Copenhagen, and the Strategy for Sustainable Urban Renewal (IGRA, 2015a). Since 2010 green roofs are mandated in most new local plans. A calculation based on approved new local plans mandating green roofs gives a total of 200.000 m^2 of green roofs to be installed. Today The City of Copenhagen has more than 40 green roofs. As part of its overall strategy to become a carbon neutral city by 2025. Copenhagen has become the first Scandinavians city to adopt a policy that requires green roofs for all new buildings with roof slopes of less than 30 degrees (The City of Copenhagen, 2012).

5.5 Singapore - The City of Singapore

Singapore has been working on a greening blueprint of the city since 1992. Their ultimate goal is to evolve into a city within a garden. With approximately 272 square miles and 4.6 million people, the biggest challenge faced is space. With 148 acres of vegetated roof space, Singapore has already made it a priority to promote green space. Careful planning has helped to conserve 9% of their total landmass as parks and nature reserves. The City of Singapore has introduced Skyrise Greenery Incentive Scheme in the period 2009 -2015. The scheme financed up to 50% of installation costs of green roofs and green walls. Singapore has focused on that as the broader urban development in the city wants to make sure that soil is not lost. The incentive scheme has provided the following objectives: support installation of Skyrise green on the existing buildings, create a distinctive image of the city in the tropical climate, promote environmental benefits such as reducing the urban heat island effect and improve air quality. In addition, Singapore's Urban Redevelopment Authority's program is intended to consolidate existing and new green initiatives and create synergies with landscape replacement policy for strategic areas; outdoor refreshment area on landscaped roof tops; exemption for communal sky terraces; and landscaped deck. Further, Singapore in 2005 launched the Green Mark Certification and Incentive Scheme, an initiative to manage Singapore's construction industry towards more environmentally friendly buildings. Several points in the scoring system can be achieved by installing green roofs and walls. Currently, Singapore's green spaces reached 47%, compared with 36% in 1986, (SkyriseGreenery, 2012).

5.6 Australia - The City of Sydney

Despite that green roofs have been part of the City of Sydney landscape since the 1930s. Much has changed in the last eighty years as the City of Sydney has evolved into an urbanized and global city, continue to experience the effect of changing climate and greater demands be placed on the city's infrastructure and green spaces. These challenges encouraged the City of Sydney to widely consult with its community and all stakeholders to use the city spaces creatively and to set ambitious targets that confirm the City of Sydney as a green, global and connected city. These targets were translated into a comprehensive Green Roofs and Walls Policy adopted by the Council in 2014 to enhance climate change resilience and adaptive capacity of the built environment. The Green Roofs and Walls Policy process started in 2008 after analyzing the community and industry perceptions, reviewing international policies and programs, giving consideration to current development and industry drivers, as well as public consultation and feedback. Furthermore, between 2008 and 2013 the City of Sydney provided funding for green roof related research to investigate the benefits of green roofs. A research priority plan was developed in 2012 to direct the City's research efforts and address key gaps in understanding of green roof technology. Then the Green Roofs and Walls technical Advisory Panel was established in 2012 to provide expert advice on advancing green roofs and walls. The policy development process promoted the benefits of green roofs through presentations and workshops to more than 1000 resident and stakeholder. The Green Roofs and Walls Policy objectives was aligned and integrated into a range of strategies and plans (e.g., Sustainable Sydney 2030, Greening Sydney Plan, Urban Ecology Strategy, Urban Forest Strategy, Decentralized Waster Master Plan, etc.) to increase green cover in the local government area. Through the policy implementation plan, the City of Sydney will provide leadership, addressing barriers to green roofs adoption and implementation (e.g., cost barriers and technical issues, etc.); supporting sustainable design through research, education, guidelines, and standards; collaborating with community, industry and all stakeholders; informing and educating the community about green roofs; supporting local practical research; supporting the recognition of green roofs in existing planning systems and rating tools; monitor and evaluating and reporting on progress (The City of Sydney, 2014).

6. Green Roof Systems in Arab Cities

The suitability of green roof systems and their adoption in Arab cities was investigated according to the following factors:

6.1 Climatic Conditions

According to Köppen climate classification, most of the Arab land classified as BWh (dry desert hot arid climate) with annual mean precipitation ≤5 mm and annual mean air temperature ≥+18 °C (Chen & Chen, 2013) as illustrated in Figure 5. Such harsh climatic conditions have always been a challenge to most Arab region's policy-makers and urban planners. Additionally, land use and urban planning regulations largely ignore basic adaptation and mitigation requirements to climate change (Verner, 2012). An estimated 75% of buildings and infrastructure in the region are at direct risk of climate change impacts and natural disasters such as droughts, floods, higher intensity and frequency of hot days, and storm and earthquakes surges (AFED, 2009; UN-ESCWA, 2014; Verner, 2012).

The United Nations Educational, Scientific and Cultural Organization report on better buildings (The United Nations Educational, Scientific and Cultural Organization [UNESCO], 2010) stated that in the temperate climates like parts of Europe and North America, green roofs have been developed and used successfully to minimize the impact of urban environment on water management and climate and to gain social, economic, and environmental benefits. However, in a hot, dry climate like that of the Arab region, flood control during single intense rain events and the indirect benefits of green roofs for energy efficiency and indoor environment might be of great importance (Scholz-Barth, 2010).

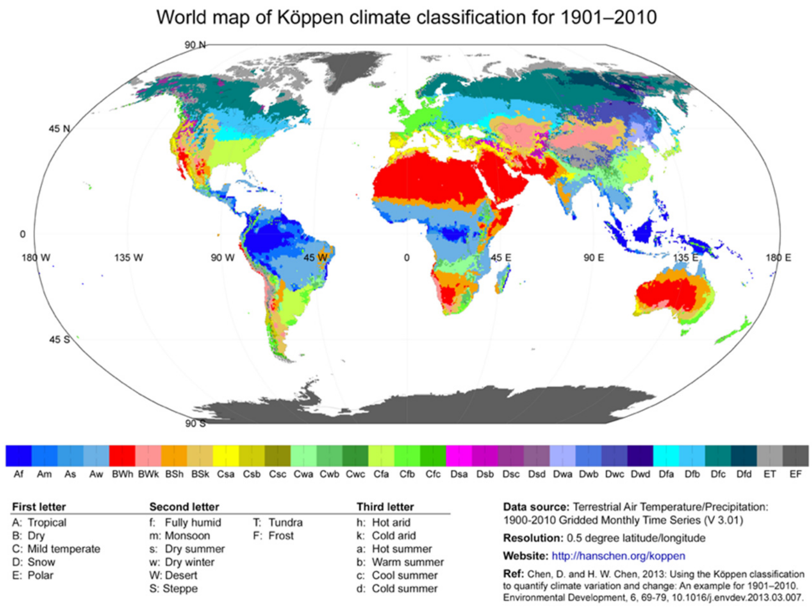

Figure 5. World Map of Köppen Climate Classification for 1901–2010 (Chen & Chen, 2013)

6.2 Policy Framework

There are no specific planning or building policies to encourage the application of green roofs in the Arab region (Al-Asad & Emtaireh, 2011; Attia & Mahmoud, 2009). National planning policy neither directly refers to green roofs, nor implicitly encompasses them in its directives and objectives to deliver development. However, there are some green building rating systems have been developed in the Arab region, in which they partially encourage having green roofs on green buildings. In addition, there are no policies against the design and installation of green roofs. Further, the Arab governments' urban agenda and their focus on high-density, quality-designed, eco-friendly development, with an increasingly environmental sensitivity, makes green roofs more likely to make an important contribution towards meeting desired objectives (Arabnews, 2014; Attia & Mahmoud, 2009).

Adopting green roof systems require policy integration between various sectors such as, building, energy, water, agriculture, etc. However, some Arab national ministries' policies -developed in silos- affect daily businesses and implementing these codes at local level (e.g., building codes, energy efficiency codes, water conservation codes, etc.). The significant inter-linkages between building policies, water resources, energy, agriculture, etc. factors should encourage planners, policy-makers and decision-makers to adopt integrated policy approach, since these sectors cannot be managed in silo anymore. Figure 6 illustrates main challenges facing Arab cities in adopting green roof policies. These challenges are mainly related to limited vertical and horizontal policy integration, institutional coordination and collaboration, etc.

Lately, policy-makers in Arab countries are gradually demonstrating greener leadership and responses to adopt green infrastructure strategies (Arabnews, 2014), which present opportunities to reduce the environmental footprint of the dense urban areas. Here, green roofs can play a significant and visible role. However, there are currently only few examples of green infrastructure and particularly green roofs in the region. The lack of explicit green roof policy or strategy in the region significantly contributed to the limited adoption and application.

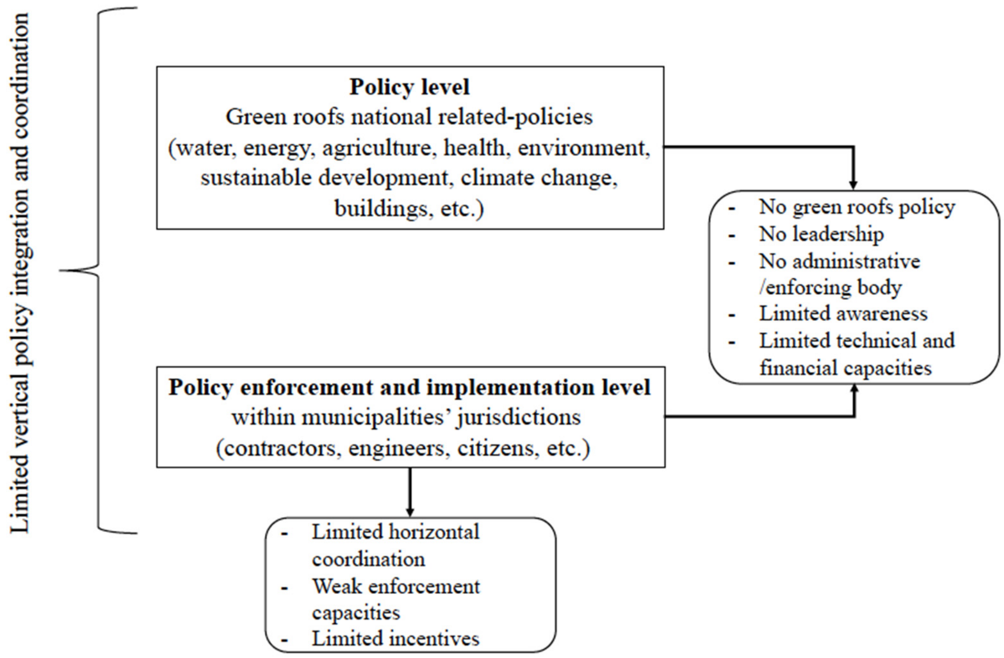

Figure 6. Challenges facing Arab cities in adopting green roofs policy

6.3 Research and Development (R&D)

The successful international experiences on green building policies and projects, demonstrate the significant role of R&D and innovation in advancing green roof industry's policies, incentives and market in Europe, United States, etc. Investing in related green roof R&D industries advanced the production and design of green roof systems. For instance, it helped in developing: new policies, financial incentives, technical solutions to manage stormwater, sustainable irrigation solutions, and innovative and sustainable perennial plant cover for green roofs create innovative vegetating systems that help to solve the growing issue of urban development, etc.

Despite the huge efforts made by Arab world towards making science, technology and innovation a priority, it still lags behind other regions with similar incomes. Due to the absence of effective research strategies and policies in some Arab countries, limited financial allocations, limited regional cooperation between Arab researchers and scientists, and science and research in the Arab world mostly state-funded, developing the Arab's research and development industries still need more investment and reforms (Veale, 2015). Motivated by the need to diversify their oil-based economies, the Gulf States have been the most proactive at promising science and technology. For instance, according to the Industrial Research Institute, Qatar has led the way in investing in science and technology by raising its spending on R&D to 2.7% of its GDP in 2014, which is higher than the Middle East average of 2.2% (Industrial Research Institute [IRI], 2016). As green building industry is flourishing in the Arab world, this could be considered as a promising window to focus, promote, and integrate green roof research and development.

6.4 Green Buildings Industry

Water, energy, and building sectors are strongly interconnected and recently are triggering Arab countries and their people to improve buildings in view of energy and water utilization and management (UNESCO, 2010). Responding to these linkages, most Arab countries have established National Green Building Councils (Bahrain, Egypt, United Arab Emirates, Jordan, Kuwait, Lebanon, Morocco, Oman, Palestine, Qatar, and Saudi Arabia). Furthermore, individual countries have formulated their own methods for assessing the environmental impact of buildings (Verner, 2012). These methods of assessment are consensus based with limited incentives to support green roof systems and technology, although the potential to enhance energy and water management with this technology is vast. Despite that no unified assessment system for green buildings was developed for the Arab region; yet, in 2009, the Gulf Organization for Research and Development (GORD) in collaboration with the T.C. Chan Center at the University of Pennsylvanian has developed the Global Sustainability Assessment System (GSAS), formerly known as Qatar Sustainability Assessment System (QSAS). It was originally developed based on understanding of the current international green building codes, with considering the climate and environmental conditions of the Arab Gulf region. The GSAS considered as the world's most comprehensive green building assessment system and one of the leading green building systems in the Arab region (Alhorr, 2015). It aims at creating a sustainable urban environment to reduce environmental impacts of buildings while satisfying local community needs. It is divided into eight sustainability categories (Alhorr, 2015; Alhorr & Elsarrag, 2015; ME*NewsWire*, 2012); those categories are weighted based on their impact toward sustainability as illustrated in Figure 7.

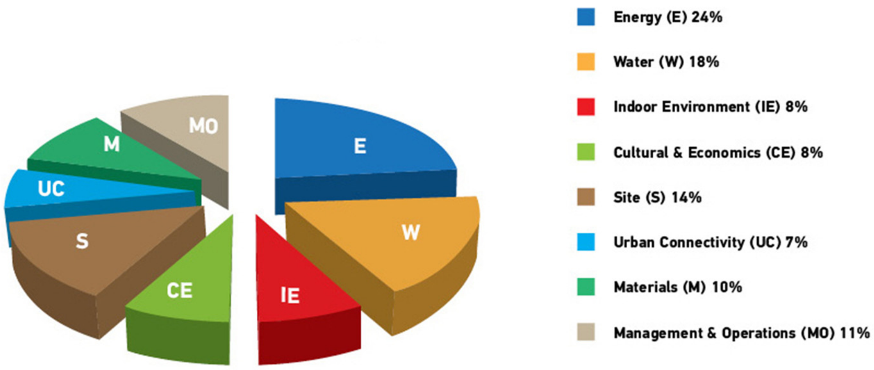

Figure 7. The Criteria of Global Sustainability Assessment System is divided into eight different categories (Source: http://www.gord.qa/trust-gsas-resource-center-overview)

Similar to other international green building rating systems, GSAS encouraged green building to integrate green roofs which considered influential for buildings in hot arid climate to help in energy savings, benefits from the available rain water, and participate in the cultural and economic values of the new construction projects (Alhorr, 2015; Alhorr & Elsarrag, 2015). It is now mandatory for all private and public sector projects in Qatar to get GSAS certification. Recently, several Arab countries (e.g., Saudi Arabia, Kuwait, Jordan, Sudan, etc.) have shown interest in the adoption of GSAS as a unified green building code for the region (Zafar, 2015).

While green roof systems have been used for centuries worldwide, introducing them into the urban environment of the Arab region is much more recent, and they started to gain popularity only in the last few years through the Green Building Councils. Implementing green roofs in the Arab countries is at its early stages of development; it is hard to find any successful examples of green roofs in the Arab region (Attia & Mahmoud, 2009), and only a very limited amount of scholarly review to document such efforts has been undertaken (Scholz-Barth, 2010).

Scholars have identified some barriers to green roof adoption and implementation in the Arab region, e.g., lack of governmental support and leadership; limited supportive policies and incentives; lack of awareness, education, knowledge, and expertise; and missing local evidence-based experimentation and practices (Attia & Mahmoud, 2009; Goussous et al., 2015; Hansen, 2015; Scholz-Barth, 2010). Moreover, the subject is still debatable; for instance, Attia and Mahmoud (2009) argued that it is impossible to grow green roofs in Arab cities owing to the extreme summers and periods of drought as well as low precipitations, i.e., 26 mm in Cairo, Egypt, 276 mm in Amman, Jordan, and 20 mm in Riyadh Kingdom of Saudi Arabia. With insufficient rainfall in the Arab countries, few plant species can survive throughout the year. In this context, discussing green roof applications may seem counterintuitive and controversial. While green roofs will have to be irrigated for plants to survive, water conservation benefits can be realized by choosing native plants (dry-tolerant species) and by irrigating with non-potable water, such as grey water (Scholz-Barth, 2010). However, Bhatt et al. (2016) investigated and tested five native legumes of the Arabian desert in Qatar. The research results revealed that these species are well adapted to the water deficient desert environment and have the potential to be used for landscaping and green roof purposes in the Arab Peninsula which characterized by exceptionally high temperatures, low unpredicted rainfall and high evaporation rates (Bhatt, Caron, Verheyen, Elsarrag, & Alhorr, 2016).

7. Proposed Conceptual Framework

According to Young and Mendizabal (2009) the relationship between research, policy, and practice is complex, multi-factoral, non-linear, and highly context specific. There is no one type of green roof, and no specific green roof system works for all projects. Carter and Laurie (2008:1) claim that "Green roof policies fall into a number of general categories, including direct and indirect regulation, direct and indirect financial incentives, and funding of demonstration or research projects". Further, green roofs are critical for earning credits in rating systems and indispensable parts of green buildings. For instance, in LEED, there are up to five sub-indexes associate with green roofs: (1) sustainable sites: site development –maximize open space (SSC5.2); (2) sustainable sites: stormwater design-quantity control (SSC6.1); (3) sustainable sites: heat island effect-roof (SSC7.1); (4) water efficiency: water-efficient landscaping (WEC1); and (5) energy and atmosphere: optimize energy performance (EAC1) (USGBC 2009). Further, green roof policy and programs in each country and municipality are unique to the local climate, environment motivators, legal framework, resources, and capacities (technical, human, and financial). Green roofs' benefits, objectives, architectural factors, locations, and maintenance should guide decision-makers as to what kind of roof to install and which system to specify.

Green roof should be viewed as an element of an integrated and multi-disciplinary policy approach towards the natural and built environment challenges. Green roofs have to be tackled within a wider national strategy that address sustainable development, as part of a package that also targets renewable energy, food security, water management, air quality, etc. this would support building up the value chain of green buildings and would reflect the holistic approach to sustainable development. However, the Arab region's current centralized policy debate, ineffective governance institutions, weak public participation, and limited interaction, coordination and integration among natural resources sectors (water, energy, agriculture, buildings, etc.) have prevented most Arab governments from engaging local governments (cities) in policy formulation debates and providing coherent policies, adequate planning, and management practices against the increased water scarcity, food and energy insecurity, climate change vulnerability , etc. (Al-Zubari, 2013; UN-ESCWA, 2015). Therefore, in the proposed green roofs policy framework, we tried to address some of these challenges and guide Arab local governments to design green roofs policy emphasizing on the vertical and horizontal policy integration and coordination.

Across the world governments have elaborated a wide variety of green roofs frameworks and policies, the development and implementation of these often follow a common policy-making continuum. To better propose integrated green roofs policy framework, this research will employ a simplified phase, relying largely on ((Lawlor et al., 2006)Ngan, 2004; Jones, 1970; Brewer & De Leon, 1983; Anderson, 1990), and case studies' experiences and diverse nature of green roofs programs as illustrated in section 5.

Accordingly, a green roofs decision-making framework was proposed to guide municipal officials to develop –in close collaboration with national related sectors- green roof policies. The integrated green roofs framework can be divided into roughly 6 phases: agenda setting, technical research, policy formulation, adoption and legitimizations, implementation, and assessment and evaluation and feedback as illustrated in Figure 8. While such a diagram is useful for Arab cities' policy-makers, we must also acknowledge the following restrictions. First this framework illustrates the big picture and major steps that might be adopted by any city; however, the city green roofs planning stage should be flexible, dynamic and iterative, involving a constant back-and-forth between activities depending on local climate, context and circumstance. Second, green roofs policy is not an isolated process, rather it should be integrated with and directly linked to other socio-economic, spatial, and environmental planning processes at the city level as well as at other levels of national government. The proposed framework was created to recognize individuals at subordinate levels and external stakeholders who are likely to play an active part in policy and may have some discretion to reshape objectives of the policy and change the way it is implemented. The framework six phases are:

Phase 1: Identification of Issues, Awareness, and Agenda Setting

There are various factors should motivate and drive Arab cities to adopt a green roofs agenda (water management, energy efficiency, food security, climate change impact, socio-economic motivations, etc.) and to explore the Strengths (S), Weaknesses (W), Opportunities (O), and Threats (T) factors for their specific context. The SWOT analysis will hopefully yield a good basis for formulating a policy advice regarding enhanced utilization of green roofs. Further, conducting series of workshops and consultations needed to bring all stakeholders together led to successful policy outcomes through community ownership of the policy goals and empowerment in projects implementation. In addition, stakeholders' knowledge and experience can significantly contribute to the policy processes (Dyer et al., 2014). It is useful at this phase to assign a core team or dedicated unit to manage the policy development process. Further, it is also helpful to exchange delegations with other municipalities with existing green roof policies and incentives. In this stage policy-makers should frame the problem through sustainable development lens. Further, they should harmonize the interests of different stakeholders and sectors, and manage the entry of an issue onto the agenda.

Phase 2: Technical Research

In the case of green roof practices and policy, a research should be conducted to investigate and quantify the benefits of green roofs (e.g., energy efficiency, water runoff management, air quality, biodiversity, etc.) that will become a foundation to develop a research-based green roof policy and design guidelines (Masum, 2013). As illustrated from the international case studies, the demonstration and pilot projects needed to identify the potential areas and climate, the technology standards, build infrastructure, regulatory framework, policy recommendations, and direct and indirect incentives. Further research will help to obtain more qualitative and quantitative information about the following significant green roof planning and design requirements illustrated in Table 3.

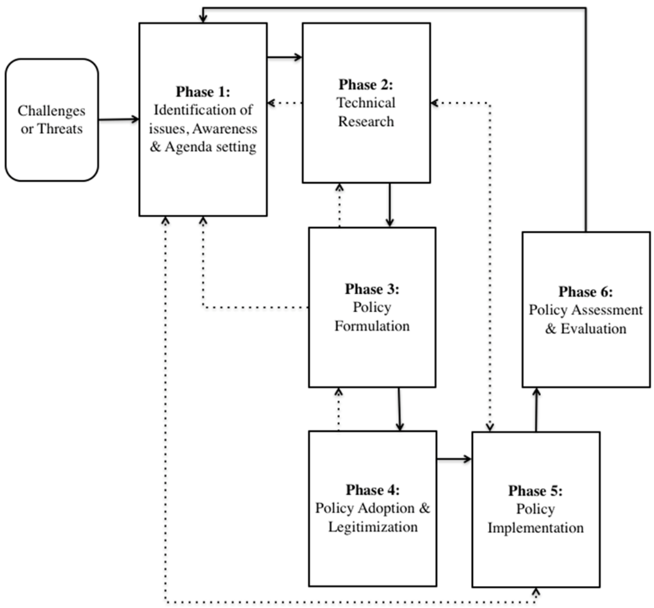

Figure 8. Proposed Conceptual Framework for Integrating Green Roof with the Current Building and Housing Policies in the Arab region

Table 3. Green Roof Planning and Design requirements

Planning Phase Features	Description
Identify the objectives of the green roof	Visual and health (e.g., public amenity, aesthetics); economic (e.g., food production, reducing heat and cooling costs); environment (e.g., increased biodiversity, water runoff management, improved air quality, reduce urban heat island effect, reduction pollution)
Identify roof substructure	Reinforced concrete, wooden substructure, metal sheeting, roof structural load capacity
Identify the local environmental conditions	Climate, rainfall, roof exposure to sun light, solar heat gain
Identify desired green roof type to achieve the objectives	Extensive green roof, semi-intensive green roof, intensive green roof Based on structural capabilities or functional requirement and roof access (installation, service, and maintenance)
Selection of plants	Ecosystem, Species diversity, locally grown, native plants
Landscape design considerations	Membranes, drainage, drainage materials, modular systems, additional load of drainage course, filter course, growing medium, types of growing medium, additional load of growing medium, planting, suitable plants, surface loads by various forms of vegetation, irrigation, types of green roof profiles
Identify architectural design Considerations	Shading and shelter, roof top rooms/meeting places
Selection of water technologies	Water collection, water storage, water use and filtration, grey water filtration, black water systems
Selection of sustainable energy technologies	Solar water heating, solar photovoltaic, wind power
Cost calculation	Cost, return on investment, subsidies, funding model, incentives, and grant programs
Management and maintenance	Installation maintenance, development maintenance, upkeep maintenance, maintenance cost
Establish database or inventory	Demonstration sites usually lead to establishment of database or inventory that can help in policy options

Phase 3: Policy Formulation

Policy formulation is the development of justifiable, doable, and acceptable courses of actions for addressing public demands (Masum, 2013). This phase looks at transforming local green roof research and obtained knowledge in to policy (White, 2012). In the case of green roofs, it helps to address green roof identified goals and motivations, concerns, objectives, expected benefits, targeted locations, and type of buildings. Policy formulation entails the selection of a destination or desired objectives. This phase involves the identification and analysis of a range of actions and formalize policy options to prepare the ground for the decision-making that respond to these concerns (UNEP, 2009b). Then, each possible solution is assessed against a number of factors such as probable effectiveness, potential cost, building standards, resources and administrations required for implementation, political context, and community support (Gregory et al., 2012; Masum, 2013). At this stage green roof policy should be aligned with national agenda and integrated with other related sectors' policies according to international case studies (e.g., water quality and management, energy efficiency, food security, sustainable development, environment protection, etc.) to avoid redundancy and guarantee effective implementation at later stages; therefore, a participatory and horizontal and vertical intersectoral coordination mechanism should be set up.

Phase 4: Policy Adoption and Legitimization

Like any new policy, green roof policy should pass the government and parliamentary approvals to be adopted and legitimatized in the form of legislation or rules for future implementation (Hajer & Wagenaar, 2003).

Phase 5: Policy Implementation

At this phase, the selected policy options should be translated into plans; however, the diversity among stakeholders involved in in this phase increases the complexity and vulnerability of implementation (UNEP, 2009b). Therefore, municipalities in collaboration with related sectors' policies should translate the green roof policy options into specific activities and targets to be achieved individually or collectively. Further this phase requires mobilize resources (human, technical and financial) proactively, and manage stakeholders' dynamics. To reduce the higher initial cost for new and existing building owners and to encourage the application of green roof systems, various incentives and instruments can be adopted and implemented.

Phase 6: Policy Assessment and Evaluation

There are many dynamics throughout the policy life cycle and the activities associated with it. Policy assessment and evaluation play a significant role in providing essential feedback about what is happening in the programs or mechanisms or practices or technologies associated with policies (Torchim, 2009). In the case of green roof policy, the results and recommendations from evaluation phase are fed back into further rounds of policymaking, this will improve the planning and implementation processes and guide the policy-makers to decide whether to continue with the current policy options or to investigate others.

8. Applying the Green Roof Conceptual Framework

The preceding sections provided an overview and outlined the context of the green roofs in the Arab Region. However, Arab countries differ vastly in terms of their climatic and urban conditions, natural resources availability and demand, socio-economic settings, demographic trends, and decision-making environment. Therefore, there is a need to more closely examine the green roof framework in the context of specific countries and cities. Two example, Cairo, Egypt, and Amman, Jordan, have been selected from the Arab region for further investigation of suitability and application of the proposed framework. This will help in understanding the current practices, challenges and what still need to be done to integrate green roof into related policies in both cities.

Cairo, Egypt

In Cairo, a city of almost 20 million people, the population lives in dramatic environmental conditions, such as pollution, dense urbanization, and urban heat island effect, with less than 0.33 m^2 of green space for each individual, the lowest proportion in the world (Attia & Mahmoud, 2009). The climate of Cairo is hot and humid in the summer with temperatures reaching as high as 35 °C and relative humidity of 62% in August, however, in winter, the temperature reaches as low as 7 ° C with relative humidity as 50% in February as shown in Figure 9. This moderate yet leaning to hot humid climate with very low amounts of precipitation in winter let building designers and builders use flat roofs in Cairo throughout history. Roofs of modern buildings in Cairo are flat and are usually made of reinforced concrete and occasionally of steel for industrial buildings. Before the use of concrete, roofs were wooden, except for some public buildings such as schools and mosques that had special roofs like domes and vaults made out of stone and brick.

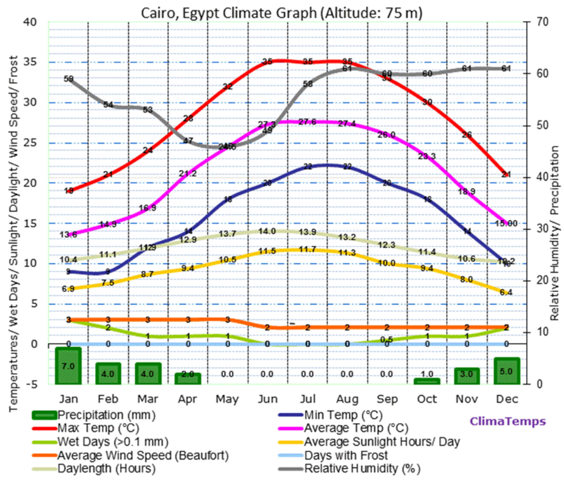

Figure 9. The Climate Graph of Cairo, Egypt (http://www.cairo.climatemps.com).

However, flat concrete roofs are not efficient in terms of building energy consumption. Although in Cairo heating, ventilating, and air conditioning (HVAC) systems were used in only commercial and public buildings for decades, there is a growing trend of having air-conditioning systems in houses and apartment buildings nowadays. This new trend dramatically affects the energy demand in summer, which is clearly seen in the government policy and the news reports of the local media in the last two years in Egypt. Moreover, flat accessible roofs in Cairo are either not made use of, so that they are full of dust and debris carried by the wind from the desert or adjacent urban areas, or they are used to install satellite dishes or as a junkyard for the stuff that building inhabitants have no need for (Figure 10**)**. This excessive amount of useless things that are stored on the rooftops of Cairo is the result of unavailability of strong recycling programs and absence of online trading of used objects, such as Craigslist.com in North America. Hence, the culture of keeping material that there is no need for until it became useless is wasteful. All kinds of materials such as wood, paper, construction debris, and old furniture get thrown out and left on the flat roofs.

Figure 10. Rooftops of Buildings in Cairo on January 9, 2014 (Photo by Khaled Desouki/AFP/Getty Images)

The performance of roofs in Cairo is limited to protecting the upper floors from the little amount of precipitation in winter and sunlight all throughout the year. Instead of participating in solving some of the environmental, social, and economic problems like roofs in big cities in the developed world, roofs in Cairo are simply causing many environmental and social problems and are not invested in any economic initiatives. From the environmental point of view, roofs are full of dust and junk and lack proper heat insulation, which contributes to building energy inefficiency. Further, they cannot be used as social interaction or for economic development for building inhabitants, especially in the informal settlements (over 100 informal housing communities in Cairo) that accommodate over 70% of Cairo's population (Kipper, 2009) and comprise 44% of the built area in Cairo (Denis & Séjourné, 2006).

The concept of planting rooftops in Egypt goes back to the 1990s at Ain Shams University, when a group of agriculture professors developed an initiative of growing organic vegetables to suit densely populated cities of Egypt. The initiative was applied on a small scale until the Food and Agriculture Organization (FAO) officially adopted it in 2001. The first roof garden (Micro/Roof-gardens) in Cairo, Egypt, was established with a purpose to fight malnutrition and poverty through the rooftop gardens. The program was specifically targeted at poorer families living in densely populated suburbs, where it would not only facilitate the availability of fresh vegetables for home consumption but also create a source of income, especially for women at home (FAO, 2011). There are some other successful initiatives of rooftops gardens applied on a small scale — to support food insecurity in urban areas — by various donors, non-governmental organizations, public institutions (schools), and private civil initiatives (Attia & Mahmoud, 2009).

According to Abdel Salam (2012), utilizing green roofs systems in residential building in Cairo demonstrates potential economic benefits (electricity saving varies from 13% to 39% compared to traditional and un-isolated roofs respectively) under different design situations and provide guidance for selection and design of green roofs systems in similar conditions (Abdel Salam, 2012). However, green roofs utilization is still limited in Cairo, owing to limited leadership and awareness, harsh climate conditions, high cost, and absence of government support, among others. In addition to improving general aesthetics, green roofs act as insulation and urban roof farming is capable of providing food in economically significant quantities. Urban green roofs provide opportunities for women to increase their incomes. Proper green roof design can reduce the heat gains of buildings.

The idea of rooftop gardening has recently gaining popularity in Cairo; however, the obstacles are myriad (Werr, 2015). Some of these obstacles are

- Ownership: deciding who has the right to the roof is an obstacle. Very few buildings in Cairo are properly registered, especially in the poorer neighborhoods where rooftops crops might provide income and benefits.
- Management: who is responsible for the services? Many electricity meters in poor communities are not registered under the name of the owner, and water meters tend to be shared, so all the building's tenants can end up financing the people irrigating and harvesting the crops on the roof.
- Building Structure: many building are old and poorly built and cannot support the extra weight of a rooftop garden.
- Cost and Microfinance: installing a rooftop garden is costly; many microfinance organizations usually ask for many documents, and it is hard for people to fulfill the requirement.

Case Study II: Amman, Jordan

Amman is the largest city and the capital of Jordan. The population growth in Amman accelerated in the last decade, and now it is home to four million people. Amman represents the main economic center of the country, with over 80% of all industrial and services activities. Historically, urban immigration and migration in Amman has increased at rates that have exceeded those of infrastructure development in the city, resulting in concentration of population and increasing of population density in the built-up areas. In Amman, while the economy is flourishing, there are still portions of the population that live in high density areas without access to reliable services as illustrated in Figure 11.

The climate of Amman is hot in the summer with temperatures reaching 33 °C and relative humidity of 42% in August. In winter, the temperature goes as low as 4 °C with relative humidity of 69% in February, as shown in Figure 12. Amman is characterized by a moderate, yet leaning to hot, climate with a high amount of precipitation (276 mm) compared with Cairo (26 mm). Roofs of modern buildings in Amman, similar to roofs in Cairo, are flat and are usually made of reinforced concrete and occasionally of steel for industrial buildings.

Similar to Cairo, the HVAC system was merely used in commercial and public buildings for decades. There is a growing trend of having air-conditioning systems in houses and apartment buildings in Amman nowadays, and this trend dramatically affects the energy demand in summer. For instance, Tewfik and Ali claim that the currently installed systems of heating, ventilation and air-conditioning have the lowest energy efficiency performance among available options. This is mainly due to the preference of applying cheaper systems over the more efficient ones. Further, old and new buildings are without adequate insulation for walls, windows and roofs, and not all the building codes are yet enforced, particularly those for green buildings (Tewfik & Ali 2014). Moreover, flat roofs in Amman with lack of regular maintenance contribute to wasting a fair amount of rainwater, and sometimes this water floods the streets. During the last three years, Amman suffered from flash flood events that overwhelmed the drainage system, as illustrated in Figure 13.

Figure 11. A Bird's Eye View for High Density Area in Amman, Jordan (SvN, 2014)

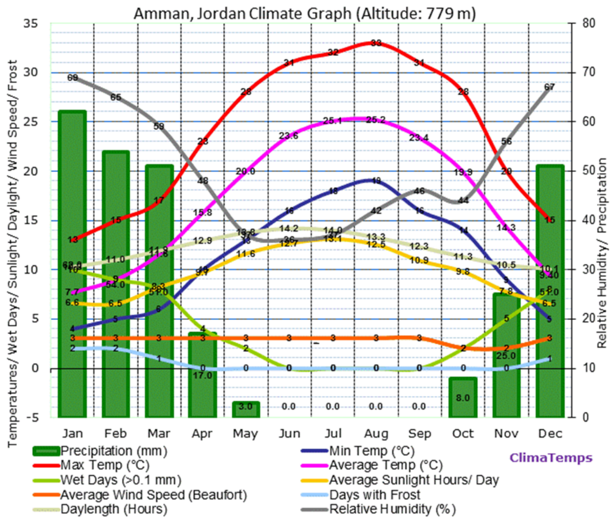

Figure 12. The Climate Graph of Amman, Jordan (http://www.amman.climatemps.com)

Figure 13. Flooded Street in Amman, Jordan, on November 25, 2015 (The Jordan Times, 2015)

Table 4. Status of Green Roofs in Cairo, Egypt, and Amman, Jordan

Green Roof Policy Framework	Cairo, Egypt	Amman, Jordan
Phase 1: Identification of Issues, Awareness and Agenda Setting	- Issues (food security, green space, air pollution, energy efficiency). - Green roofs were donor-driven initiatives (e.g., FAO and Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) or private initiatives. - Green roof initiatives are still scattered and do not have any vast public effect. - The problem with the green roofs project is lack of information and lack of know-how. - The issue that may face the implementation is that roofs are often fully accessible and are often used to dry laundry or to hold social events like weddings and other celebrations.	- Issues (food security, green space, storm-water management, and energy efficiency). - Greater Amman Municipality (GAM) established in 2006 the Urban Agriculture Office (UAO) and started its official urban farming program in 2006 as part of an urban agriculture (UA) and food security initiative. Through this initiative the UA has become an integral part of the agenda of the municipality. More than 400 rooftops gardens were established in Amman. Unfortunately, the UAO was merged with the Parks Department in 2015, which makes it less of a priority for municipality officials. - GAM conducted several awareness workshops, training, and consultation meeting with beneficiaries (2006–2009). - Green roofs were introduced by individual initiatives of the private sector in 2009. - GAM in 2006 joined a regional initiative concerning the Urban Agriculture; 100 houses were selected to establish some urban agriculture activities like rooftop gardens. - Green Amman City by 2020 Plan. An ad hoc committee assigned by the GAM "Amman is a Green City" Committee was established in 2015. The aim is to increase the green space of Amman from 2.5% to 5% in 2020.
Phase 2: Technical Research	- Limited technical research. - In Cairo, soil-less agriculture is used to grow plants on the roofs of the buildings. It is known as "container gardening" and is considered to be less formal and cheaper than other methods. - Limited successful case studies of roof gardens including schools and residential units (Attia & Mahmoud, 2009) - Along with the project developed under the FAO project. Ministries of Agriculture and Education produced and distributed an illustrated technical booklet to raise awareness and to assist people to produce vegetables and increase public awareness.	- Limited technical research. - Limited green roof demonstration sites in Amman (rooftop gardens)
Phase 3: Policy Formulation	- No green roof policy exists at the national or municipal levels. - Green roofs are not integrated into other sectors' policies (e.g., water, energy, etc.)	- No green roof policy exists at national or municipal levels. - Green roofs are not integrated into other sectors' policies (e.g., water, energy. etc.) - Some incentives through the Greater Amman Municipality between 2006 and 2009 through the Urban Agriculture Initiative. - Green roofs have been integrated into the Green Building Assessment through the Jordan Green Building Council (Voluntary).
Phase 4: Policy Adoption and Legitimization	No green roof policy adopted.	No green roof policy adopted.
Phase 5: Policy Implementation	No green roof policy adopted.	No green roof policy adopted.
Phase 6: Policy Assessment and Evaluation	No green roof policy adopted.	No green roof policy adopted.

Expanding the green space in Amman is not a new idea; it has always been on the Amman Municipality's agenda. However, most initiatives started but were not sustained due to limited leadership, funds, awareness, and commitment, among others. The result is that green space does not exceed 2.5% to the total area, which is 1680 km^2 (Whitman, 2013).

The importance of agriculture in food security on the one hand and maintaining a clean environment on the other hand led the Greater Amman Municipality (GAM) in 2006 to establish a specialized Urban Agriculture Unit with dedicated human and financial resources, which gives solid sustainability and institutionalization prospects for the agenda. The program has so far beautified the surfaces of 110 homes (rooftop gardens) mostly in the eastern regions (poor and informal settlements) and included clean surfaces, cosmetic and cultivated. In the third most water-scarce country in the world, Jordan, expending precious water on household plants may seem like a luxury Jordanians cannot afford. Therefore, through this program GAM has also been teaching urban agriculturalists efficient water usage through grey water recycling systems, irrigation techniques, and rainwater catchment.

Urban farmers in Amman were recognized by the Agricultural Credit Institution through opening new microcredit opportunities for small-scale urban farmers. In addition, the extension department at the Ministry of Agriculture targeted its services towards urban producers by offering training and in-kind subsidies. Although they are a longstanding practice in developed countries, green roofs in Amman are still individual trials that are far from the government policies and common design practices and which receive poor recognition from agricultural scientists, policymakers, researchers, and even practitioners.

According to an agricultural and landscaping engineer, who established in 2010 a landscaping company - specifically for green roofs and walls- in Amman said, "*The company was the first of its kind in the Middle East region. We worked very hard on introducing this new concept in Jordan by organizing seminars, distributing materials, networking with governmental and private institutes, and we made designs and offers all over the place. We also represented companies from Europe and the United States that work with green roof materials and tried hard to market it. However, the concept just did not pick up. People were initially interested but the cost was the main limiting factor. After four years of unsuccessful trials to implement green roofs systems, we decided to close the company*".

Table 4 illustrates green roof status in Cairo, Egypt, and Amman, Jordan, based on the proposed Green Roof Policy Conceptual Framework outlined in section 6.

9. Concluding Thoughts

The Arab region is becoming increasingly urbanized, and with this accelerating process more challenges emerge. Cities can have an impact on the surrounding fragile ecosystem and increase pressure on already scarce natural resources (water, energy, and food). In such a case, implementing sustainable and environmentally friendly techniques are becoming more essential. While green roofs have been used for centuries to reduce negative urbanization impacts, their introduction into the Arab region urban environment is much more recent, gaining popularity only in the last few years through the Arab Green Building Councils.

As sustainable green roof techniques emerge, the methods for bringing them into use in the Arab region must try to keep pace with development and population growth, and that will require high-level commitment and innovative and unconventional policies. Arab cities with prolonged hot summers and limited water resources require custom-made design, innovative irrigation techniques, plant species that are particularly heat and drought tolerant, and longer periods of initial maintenance with irrigation.

The green roof objectives are site specific and diverse, which may lead to different designs, policies, and incentives. Therefore, applicability in the Arab region will vary according to the local context and the objectives, which might be storm-water management, food security, energy efficiency, or reducing urban heat island.

Green roofs may provide significant direct and indirect benefits for the Arab region, such as cooling effects in summer by protecting the roof against direct sun exposure and thereby reducing the solar heat gain of the building; reducing energy consumption for heating in winter; mitigating urban heat island effects and enhancing indoor environments; mitigating the impact of imperviousness surfaces, e.g., flood control during single short rain events; contributing to food security efforts in urban poor communities; adding green spaces, wildlife habitat, air filtration, and dust control; and aiding in creating sustainable communities despite the hot climate and water scarcity (Hansen, 2015; Scholz-Barth, 2010).

Most Arab municipalities and local administrations limitedly engaged in developing buildings-related policies and do not have full executive authority to deal with building and construction sector violations. The proposed Green Roof Policy Conceptual Framework demonstrates that both Cairo and Amman are still in the early stages of integrating green roof systems into municipal planning and decision-making processes. The policy framework in urban areas requires multilevel cooperation among local and national levels and partnerships to mobilize public and private resources. Likewise, stakeholder consultation and engagement is important.

The conceptual framework proposed in this article is an important step needed for future research required to develop effective local policies towards a potential urban sustainability in the Arab region, this framework shows, with simple steps, the possibility of integrating green roofs into building sector policies and encourage the municipalities to take action even with the current challenges they are facing. More in depth investigation and research needed to adapt this conceptual framework to governmental policies in the Arab world based on the level of environmental policies they have.

While, findings are context specific given that we examined only two case studies (Amman and Cairo). In this paper, we provided detailed and substantial description about the subject under investigation, research problem, research methods and data collection strategies, results and findings, etc., to allow the readers to make an informed judgment about whether they can transfer whole or certain aspects of the research approach and methodology to their own situation. The findings are also likely applicable to other cities that are facing similar challenges and attempting to integrate resources utilization efficiency and urban sustainable livelihood initiatives through collaborative governance to achieve urban sustainable development.

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