

Guideline for Designing Rooftop Gardens in Amman Buildings

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Abstract

The aim of this study is to create a guideline for rooftop gardens in the city of Amman, taking into account the factors of social, environmental, and economic sustainability, and in a way that is largely consistent with the local building systems and regulations. Local libraries lack a guideline specialized in rooftop gardens, how to design and implement them, and choose the appropriate materials for them. The failure to exploit the unused rooftops of buildings in the city of Amman results in many environmental and architectural problems that this research found in order to address them, by providing diverse, accurate and standard information that facilitates the work of people interested in establishing rooftop gardens. To reach the desired goal of this research, many interviews were conducted with gardeners, experts and officials in companies with local and international sustainable products, in addition to experts in irrigation systems, monitoring and outdoor lighting. The information obtained by the researchers was tabulated through tables through which it is easy to access the information. The research outcomes are expected to develop design guidelines for the utilization of rooftop gardens in the city of Amman which respond to principles of sustainability, whether social, environmental or economical, as well as the result highlighted the importance of the guideline and the benefits that it can be brought to the city and its inhabitants from the environmental, social and even economic aspects.

Keywords: Guideline; rooftop; garden; Amman; buildings.

الدليل الإرشادي لتصميم حديقة السطح في مباني عمان

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ملخص

الهدف من هذه الدراسة هو إنشاء دليل إرشادي لحديقة الأسطح في مدينة عمان، ضمن عوامل البيئة والاقتصادية، والاستدامة الاجتماعية، وبطريقة تتماشى إلى حد كبير مع أنظمة ولوائح البناء المحلية. وذلك لافتقار المكتبات المحلية إلى دليل إرشادي متخصص في حدائق الأسطح وكيفية تصميمها وتنفيذها واختيار المواد المناسبة لها. كان لعدم استغلال أسطح المباني السكنية القديمة في مدينة عمان العديد من المشاكل البيئية والمعمارية التي استطاع هذه البحث الوصول إليها وإيجاد الحلول المناسبة لها، من خلال توفير معلومات متنوعة ودقيقة وموحدة تسهل عمل الأشخاص المهتمين بإنشاء حدائق على الأسطح. جرى إجراء العديد من المقابلات مع الخبراء والمسؤولين والفلاحين في الشركات ذات المنتجات المستدامة المحلية والدولية للوصول إلى الهدف المنشود من هذا البحث، بالإضافة إلى خبراء في أنظمة الري والمراقبة والإضاءة الخارجية. ومن ثمّ جربوضع المعلومات التي حصل عليها الباحثون بجدول منظمه تمثلت بنتائج هذه المقابلات. توصلت نتائج البحث إلى إرشادات تصميمية لاستخدام حدائق الأسطح في مدينة عمان ضمن مفاهيم الاستدامة، والطقس الاجتماعي، البيئي والاقتصادي، ومن ناحية أخرى أبرزت تلك النتائج أهمية الدليل الإرشادي وفوائده بيئيًا واجتماعيًا واقتصاديًا. الكلمات الدالة: الدليل الإرشادي، حديقة السطح، عمارات عمان.



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1. Introduction

Rooftop Gardens provide us with a unique chance to transform thousands of traditional roof surfaces to green life-giving" environments. In addition, green roofs support biodiversity, the rooftop garden helps in the absorption of rainwater in a sustainable way as well as it will decrease the Global Warming. Therefore Rooftop Gardens might be part of Amman city future urban plans for a more sustainable city, they also support social interaction if designed well.

This research would be very important for the users of rooftop gardens, designers, and academics in Amman. Choosing green roofs has plenty of benefits such as providing open spaces, good air quality, producing food and reduces sound pollution, over and above rooftop gardens help in public relations and have a satisfying value.

In this paper, a proposed method is suggested to obtain sufficient information for developing design guidelines for green roof system in Amman, the capital city of Jordan. For instance, Hui (Hui, S. C. 2016), has developed technical guidelines for green roof systems in Hong Kong. Other countries like Germany, Canada, Japan, and USA have their own guideline has been standardized. Barnhart, & et al. (2021), discusses the design of green roofs in USA with details on system components, maintenance, cost issues, and the possible applications.

Ismail talked about controlling or reducing air temperatures by using green roofs and the indoor air temperature of the room can be reduced by using potted plants on top of the roof (Aziz, H. A., & Ismail, Z. (2011), Green roof is important also in reducing sound waves, because green surfaces can lead to a steady and significant drop in sound and on reducing the amount of CO₂ in the environment by absorbing it.

Following the same line of researcher in United Arab Emirates (UAE), they have managed to develop and follow a specific design guideline for Green Roof system that contains planning, execution and maintenance of green roof (Altan, H., et al. 2019).

Amman designers on the other hand still struggling to have a fixed local guideline to come out with the best solutions for Jordanian industry on green roof systems. The studies and guidelines of other countries are inapplicable in Jordan because of the environmental variations. Yet, they are usable in terms of research development, therefore, this study tends to reach a better understanding for the rooftop garden system and to come up with a qualified green roof system to adapt in Jordan.

1-1 Research Problem:

The problem is that there is an urgent need for a guideline for rooftop garden design in the capital city of Amman, so the lack of such reference has led to social, environmental and economic problems that need to be solved. Architecturally, the exploitation of rooftop spaces in Amman is very beneficial socially and economically. Therefore, this study came to confirm the need to design a guideline for rooftop gardens in the city of Amman in a way that responds to the principles of social, environmental and economic sustainability that contains quantitative and qualitative criteria in terms of area and appropriate types of crops.

1-2 Research Objective

The aim of this study is to design a guideline for rooftop gardens in the city of Amman that achieves environmental, social and economic sustainability that includes quantitative and qualitative standards.

Significance of the Research

The researchers managed to turn the summary of all previous research on the green roof system into a road map that supports the creation of a special design guideline for Jordanian green roof system to get the ultimate benefit of it and overcome its obstacles.

This research could serve widely the city of Amman, and some Arab cities that have similar environment and culture, by using it as a reference for the official bodies involved in city planning, as well as for the city's residents.

2. Guideline Introduction

Amman the capital city of Jordan has a prospering and rapid development life style, especially in the field of design and architecture, this change is accompanied by the increase of population, what causes big shortages of green spaces and recreational areas. Designers have to create new ways to exploit unused spaces in the city while at the same time support the

environment. So that rooftop garden has been chosen as an innovative solution in green space utilization and environmental development. But what is “Rooftop garden”?

2.1 Rooftop Garden

Unexploited roofs are one of the most modern and raw resources that, if exploited, will solve a wide range of problems by increasing green areas and reducing the problem of global warming in addition to air cooling and water recycling and could easily be turned into green roofs on the top of schools, apartments, houses and places throughout Amman. So, rooftop garden is the top of a building that can be rehabilitated to create a green area covered completely or partially with ornamental plants or vegetables in an attempt to make the urban life productive and sustainable. (Khan, K. M., Ahmed, N., & Ali, F. 2012, July)

2.2 Key Things to Consider in the Design of Rooftop Gardens in Amman

There are some ideas to reduce the roof's load such as; using a light weight growing mediums, making the soil lighter by adding organic matters, controlling the activities on the roof, controlling water flow, using light weight decks and finally using a small and light weight plants. (Al-Zu'bi M. & Mansour O. 2017).

2.2.1 Climatic and Environmental Factors Affecting Roof Design in Amman

- **Wind:** In Amman the most wind is seen in July, while the least wind is seen in September. <https://weather-and-climate.com>
- **Rainfall:** it is important to bear in mind Amman's rainfall seasons that February is the wettest month. While August is the driest month. Therefore, the design of a green roof must work on drain excess water in wet days to prevent water stagnation and mosquito breeding and works on watering plants in dry days. <https://weather-and-climate.com>
- **Temperature:** there are mild climate plants that are well suited to Amman's atmosphere and can be used to improve the quality of green roofs. The months April, May, October and November have a nice average temperature, for example the hottest weather is in summer between May, July, Aug & Sep. but the warmest one is in Aug. while the coldest month is Jan. <https://weather-and-climate.com>

2.2.2 Vegetation & Greenhouses: Alkhalidi, A., Khawaja, M. K., & Abusubaih, D. (2020)

2.2.3 Planting Growing Medium: Zamin, M., Muhammad, A., Jan, I., Ullah, H., Shah, S., Amin, M., & Rashid, H. U. (2020).

2.2.4 Root Barrier: Mahdiyar, A., Mohandes, S. R., Durdyev, S., Tabatabaee, S., & Ismail, S. (2020).

2.2.5 Waterproof Membrane and Insulation: Habibi, S., Obonyo, E. A., & Memari, A. M. (2020).

2.2.6 Structural Support: (Khan, K. M., Ahmed, N., & Ali, F. (2012, July)

2.2.7 Irrigation: Parada, F., Gabarrell, X., Rufi-Salís, M., Arcas-Pilz, V., Muñoz, P., & Villalba, G. (2021). In Amman rooftop garden people can use two kind of irrigation systems as follows:

Wicking bed & Hydroponic systems in the Gaza Refugee Camp in Jerash. 2017 (https://greeningthecamps.com/portfolio_page/jerash-camp/).

2.3 Maintenance, Choosing plants, Soil depth, Seating, Materials & Design Process

2.3.1 Design Process: The rooftop garden design process is associated with many factors that control the success of this design such: Geometric designs, layering shapes, overlapping layers, Circular Designs, Shapes on a diagonal, Organic shapes, and Introducing Height, Sculptural Structures or Multilevel layouts. Zhang, G., & He, B. J. (2021).

2.3.2 Design Elements: Furniture, Lights colors well between flowers and plants Barbeque, Social series & fountains, Dura, Arbors obelisk & Games: There are many Single and group Games suggested for rooftop garden like foosball table, chess, mine golf, domino, Ludo, snake and Ladder game, Chess table, golf pool and domino. Chen, X., Jeong, et al. (2020).

3. Methodology:

This paper is involved with sustainability (social, environmental and economic) as a first step in improving the sustainability standards of Amman city. In this type the researchers used qualitative approach by using open unstructured interviews with a variety of experts from the local market in Amman.

The criteria used to select material in this research related to the suitable plants, vegetation, irrigations, elements of

designs, cultural values, art and sustainable materials, and successful insulations found in Amman to design rooftop garden. Data originally was produced from many types, for example: companies inside Amman or from other Jordanian cities like Madaba, Petra, etc., or from international markets.

Data about local and international materials and products were sourced from five different landscaping companies in Amman, local and international, by unstructured interview with three experts in rooftop insulations in Amman. Eng. Bashar Al Bitar, Dr. Yassin Al Isawi, Eng. Rami Abu Ghoush. While in the international and local products and materials, the interview and site visit made with JRF (Jordan River Foundation) and its parts: first one was The Bani Hamida Women's Weaving Project in Madaba, second was Wadi Al Rayan project, the thirds was Al Karma Embroidery Center and Stones Jordanian Company in Amman for Local Jordanian eco-friendly environmental Products & materials, Nahar Al Fonoon cultural center for the traditional pottery, ceramics and mosaic in Madaba, also the data for lighting sourced from the interview and site visited with AVE and Noor Ala Noor company in Amman, can find it below:

3.1 List of Unstructured Interviews of Gardeners in Amman.

This list was developed after analyzing the collected data concerned with plant selection. The main source of data was the unstructured interviews conducted with professionals, gardeners, and case studies local and international. The following is the list of unstructured interviews conducted with gardeners from in the plant sale market. See table 1

Table (1). List of Unstructured Interviews of Gardeners in Amman

No.	Plant Sale Market (landscaping)	Personnel Interviewed	Profession	Date
1	Ard & Ward	2	Gardener & officer	All interviews were conducted in October-november 2019 Average time for each was 30 minutes.
2	Shamsofai	2	Gardener & officer	
3	Lana landscaping	1	Gardener	
4	Garden city	1	Gardener	
5	Al-Qaderi plant shop	1	Gardener	

3.2 List of Unstructured Interviews of Sustainable Art, Material, lighting and Roof Garden Design Elements in Amman

This list was developed after analyzing the collected data concerned with local product selection and international product in the Jordanian market. The main source of data was the unstructured interviews conducted with professionals, in the labor market, companies and Jordan River Founder experts, Average time for each interview was from 2-4 hours. The following is the list of unstructured interviews conducted with Jordanian professionals in labor market. See table 2

Table (2). List of Unstructured Interviews with Experts of Sustainable Art Materials, Lighting and Garden Design Elements in Amman

No.	Sustainable Art Company Name	Product Source	Personnel Interviewed	Profession	Date of Interview
1	Stones co. in Amman	local products	2	Eng. Rami Abu Goush	Nov. 2019
2	Statia co. in amman	International products	2	Eng. Omar Hada	Sep. 2019
3	JRF(Jordan river founder) Bani Hamida in Amman	Local products	1	Ahmad Ghnimat	Dec. 2019
4	JRF(Jordan river founder) wadi al rayan showroom	Local products	1	Ammal Al fitiani	Dec. 2019
5	JRF(Jordan River Founder) Al Karma Embroidery Center showroom	Local products	1	Ahmad Ghnimat	Dec. 2019
6	Nhar al Fonoon bazar in Madaba	Local products mosaic stone and plastic	2	Samer Twal	July 2012
7	AVE co. for outdoor lighting	International products	1	Mostafa Yaquob	Nov. 2019
8	Noor Ala Noor co. for outdoor lighting	International products	1	Noor Abu Diyah	Nov. 2019

4. Analysis and Findings:

4.1 Gardener Unstructured Interviews:

These interviews focused on two main parts: first one is to what extent people of Amman interested in roof gardens and how that appears in their sales. The second is the main types of plants they like to use for gardening.

Interviews revealed a list of plants could be grown easily in Amman rooftops, as well as the case studies of rooftop gardens selected in our research suggested some of the plants vegetables, herbs and fruits that that we listed in our recommendations. Herbs, vegetables and fruits could be used for kitchen gardens on roof tops, some of them could be used for ornamental purposes also. Interviews revealed that people in Amman are interested in roof gardening. Some of the gardeners in the market have the experience of establishing rooftop gardens in Amman. One of the interviewed gardeners pointed that he was involved in establishing 10-15 rooftop gardens the last year, which is very modest number compared with the inhabitants of Amman.

Interviews with salesmen and gardeners shown that small trees, vines, shrubs, perennials, and some other types of ornamental plants could be easily applied on rooftop gardens in Amman.

Many hybrid plants are in the market now, some of these have similar native ones such as lavender, geraniums and others, and they have been grown successfully in Amman gardens according to the plant sellers.

4.1.1 List of Planting Systems Revealed in Amman Roof Top Gardens:

For economical uses some types of vegetables like lettuce and some types of kitchen herbs like thyme, basil, and rosemary are easily applicable for a small kitchen garden on rooftops. The use of trellis and vertical gardening are applicable in economical gardening.

A notable case study is the Belgian ambassador house in Amman in where he planted vegetables, herbs and some ornamental plants in raised beds.

The use of hydroponic growing systems could be applicable in Amman roofs as documented in the Center for the Study of the Built Environment (CSBE) article concerned with urban agriculture in Amman.

The use of 40 cm or less thicknesses containers or built-in planting beds or raised beds may be a safer solution for existing built roofs in Amman. See table 3.

Table (3). List of Planting Systems Revealed for Rooftop Gardens in Amman

Planting System	Comments
Typical Containers and pots this system Includes	A very typical system in terraces and rooftops in Jordan many types.
Raised beds or wicking beds	This system was used also by greening the camps initiative.
hydroponic beds	This system was used by greening the camps initiative
Built in beds.	New built in beds were installed on an existing roof building.
special types of containers	Similar types of containers were used in Amman rooftop gardens as revealed by unstructured interviews with gardeners in the market.
Vertical gardening which includes many techniques an example is shown.	Also used by greening the camps initiative.
Reused materials for planters & containers. Such as tires, sacks, wood etc.	Could be extended low economic roof top gardens

4.1.2 Recommended Plants for Roof Top Gardens in Amman:

The suggested list could be adopted on existing built roofs or in the case of establishing new buildings with rooftop gardens. In general, most types of plants that are used in Amman residential gardens could be used in rooftop gardens taking in consideration that trees that need deep rooting systems may not be applicable in rooftop gardens. Some trees may live with 50-60 cm thicknesses of soil if planted in large containers, as mentioned by plant sales men.

For economical uses some types of vegetables like lettuce and some types of kitchen herbs like thyme, basil, and rosemary are easily applicable for a small kitchen garden on rooftops. The use of trellis and vertical gardening are applicable in economical gardening. A notable case study is the Belgian ambassador house in Amman in which he planted vegetables, herbs and some ornamental plants in raised beds. Issues of dead load and weights of material are of major importance also. The use of lightweight soils could solve the problem. A simple isolation technique also could be adopted in existing roof.

We need to provide each plant with its proper microclimate such as issues of orientation, sun exposure and shading devices, wind, soil and nutrition also must be taken in consideration.

Efforts to make the list as comprehensive as possible, additional types may be added within time. Most of the mentioned plants are planted in Amman, the list is classified into herbs, vegetable trees, shrubs, vines, and miscellaneous. The list in the first two tables shows various types of plants, vegetables & fruits, herbs, small trees, shrubs, vines, and miscellaneous that were planted on roof gardens in Amman and used as food supplies. See tables 4, 5, 6, 7, 8, 9.

Table (4). List of Vegetables and Fruits Recommended for Rooftop Gardens in Amman

Scientific Name	Common Name
Lettuce	Lettuce
Tomatoes	Tomatoes
Cucumber	Cucumber
Red Pepper	Red Pepper
Carrots	Carrots
Zucchini	Zucchini
Egg Plant	Egg Plant
Lemon	Lemon
Citrus Japonica	Kumquat

Table (5). List of Herbs Recommended for Rooftop Gardens in Amman

Scientific Name	Common Name
Rosemarinus Officinalis	Rosemary
Thymus Vulgaris	Thyme
Santolina Chamaecyparissis	Lavender Cotton
Lavandula Angustifolia	Lavender
Basil	Basil
Salvia Officinalis	Sage
Melissa Officinalis	Melissa
Matricaria Chmommilla	

Table (6). List of Recommended Small Trees for Rooftop Gardens in Amman

Scientific Name	Common Name
<i>Cycas Revolute</i>	Sago Palm
<i>Cupressus Macrocarpa</i>	Goldcrest
Thuja Orientalis	Thuja
Chamerops Humilis	Chamaerops
Magnolia Grandiflora	Magnolia
Laurus Nobilis	

Table (7). List of Recommended Shrubs for Rooftop Gardens in Amman

Scientific Name	Common Name
Juniperus Horizontalis	Juniper
Agapanthus Orientalis	Lily Of The Nile
Berberis Thumbergii	Barberry
Carrisa Macrocarpa	Intal Palm
Lantana Camara	Lantana
Pennistum Setaceum	Fountain Grass
Phormium Tenax	Newzealand Flaxroof
Euonymus Japonicas	Euonymus
Buxus Sempervirens	Boxwood
Yucca Alloifolia	Spanish Bayonet

Table (8). List of Recommended Vines for Rooftop Gardens in Amman

Scientific Name	Common Name
Bougainvillea	Bougainvillea
Plumbago Capensis	Plumbago
Jasminum Officinale	Jasminum Officinale
Lonicera Japonica	Lonicera Japonica

Table (9). List of Miscellaneous Plants Recommended for Rooftop Gardens in Amman

Scientific Name	Common Name
Pelargonium Hortorum	Geraniums
Gardenia Jasminoide	Gardenia Jasminoide
Salvia Coccinea	Sage
Argyranthemum Frutescens	Marguerite
Dosanthemum Floribundum	Rosea Ice Plant
Drosanthemum Floribundum	Drosanthemum Floribundum
Cyclamen Persicum	Cyclamen Persicum
Coreopsis Auriculata	Coreopsis
Asparagos Fern	Asparagos Fern
Narcissus	Narcissus
Iris	Iris
Zantedeschia Aethiopica	Cala Lily

Many other types could be added to this list such as types of bulbs, perennials, and most of the types that could be planted in containers.

4.2 Analysis and Findings of Unstructured Interviews with Companies of Sustainable Art, Material, Lighting and Roof Garden Design Elements in Amman:

The interviews focused on three main parts: first one was best suggestion used of the cultural values in local products like: furniture, accessories, and flowerbeds of Amman rooftop gardens. The second was about the best suggestion used of the international sustainable art products, materials in rooftop garden, third one was about the lighting, fourth was about the successful way of rooftop insulations in Amman.

Interviews revealed a list of materials and products emphasis the Jordanian cultural values could be used easily in Amman rooftops. On the other hand, the site visit covered and suggested some of the best materials, furniture, flower beds and plants, stone mosaic products and plastic mosaic products, could be used in floor, wall, plate jars, sculpture, beds & candle holders,

listed in recommendations below.

Interviews with sales men in labor market shown that small accessories, low weight sustainable furniture, materials and pergola could be easily applied on rooftop gardens in Amman. Little number of Amman residents are having the ability to do that.

4.2.1 Sustainable Art (local products) Jordan River Designs

The Jordan River Foundation (JRF) is a non-profit, non-governmental organization, chaired by Her Majesty Queen Rania Al Abdullah, established in 1995 with a focus on community empowerment.

JRF implements various programs to achieve its mission of transforming Jordanian communities. It has also been supporting homegrown solutions that help Jordanians address local challenges. The Foundation's mission is to promote, in partnership with stakeholders, the development of a dynamic Jordanian society by supporting sustainable social, economic and cultural programs.

Empowering individuals and communities are one of the most important objectives to the Jordan River Founder. Participation, innovation and sustainability continue to be the underlying themes in these income-generating handicraft projects that must take consideration, especially in rooftop gardening.

4.2.2 Al Karma Embroidery Center

Al Karmah Embroidery Center, located in Jabal Al Natheef, established in 1996, employs local women artisans who craft traditional and contemporary handmade embroidery products, like furnishings, tables, boxes, gifts, fashions, and accessories. This project aims to maintain and promote the heritage of handicrafts, offering a variety of products of Jordan's traditional arts.

4.2.3 The Bani Hamida Women's Weaving Project

Today, Jordanian older women in thirteen villages of the Makawir area, helps keep the traditions alive, by pass on rug weaving techniques to the younger women, on the other hand they create a candle-making project as one of the local economic activities. Over one 1600 woman have benefited from the project since its inception in 1998.

4.2.4 Wadi Al Rayan Project

In 1997 Wadi Al-Rayan Project was established to gives the opportunity of 100 women in the area to improve their economic and social status while reviving their traditional skills by using cattail reeds and banana leaves to produce hand-woven friendly environmental products, like furniture seating, baskets, coasters, lighting elements and mats etc. See table 10

Table (10) Sustainable Art (Local Products) Jordanian Company Designs

Name of the Local Product and Manufacturer	Product Specification
Table created by Wadi al Rayan	Metal table with 2000 grams of woven banana leaves. With different sizes
Sustainable hand-woven Basket. Created by Bani Hamida	Hand-woven banana leaf baskets
Sustainable hand-woven Lighting unit. Created by Wadi Al Rayan	Baskets made of braided cattail reeds dipped size: Large 18x22cm
Wooden table Created by (4) women over the course of (15) days in JRF	Circumference: 35 cm Color: Multi colored, Weight: 2.7 kilo Material: Wood, metal, and hand-embroidered linin
Wool & Wood Baby Chair. Created by (3) women over the course of (10) days in JRF	Height: 45 cm, Width: 30 cm Color: Green, Weight: 665 gram Material: Wool and wood
Wool & Wood Chair. Created by (6) women over the course of (15) days in Bani Hamida	Height: 85 cm Width: 50 cm Color: Green Weight: 665 gram Material: Wool and wood

Name of the Local Product and Manufacturer	Product Specification
Wood, and hand-embroidered red linin. Created by (4) women over the course of (15) days. In JRF	Height: 50 cm, Width: 40 cm Color: red, Weight: 2.7 kilo Material: Wood, metal, and hand-embroidered linin
Rocking Horse Decoupage Ornament. Created by (5) women over the course of (6) days. In JRF	Height:19 cm, Width:30 cm Color: Blue, Weight: 170 gram Material: Wood
Hand-Embroidered And Lazer Engraved Candle Holder. Created by (7) women over the course of (15) days In JRF	Size: Large, Height: 23 cm Width:14 cm, Color: Black Weight: 990 gram
Akka” Backgammon Hand-Embroidered Box Created by (10) women over the course of (20) days In JRF	Height: 20 cm, Width: 45 cm Color: Multi-colored, Weight: 234 gram, Material: Wood and hand-embroidered linin
Pure Wool Trivet, Three Colors Created by Bani Hamida	Handwoven 37x1.5cm dyed trivet made of pure sheep wool.
Embroidered Flowers” Wooden Side Table Created by (5) women over the course of (10) days In JRF	Height: 25 cm,Width: 25 cm Color: Purple, Weight: 4.2 Material: Wood, Plexi, and hand-embroidered linin
The Colors Of Palestine” Hand-Embroidered Stool. Created by (7) women over the course of (35) days in JRF.	Height: 36 cm, Width: 50 cm Length: 44 cm, Color: Multi-colored, Weight: 3.64, Material: Wood and hand-embroidered linin
Abstract Print Hexagonal Decoupage Tray Created by (4) women over the course of (7) days in JRF.	Height: 18 cm, Width: 29 cm Color: Blue and Purple Weight: 190 gram, Material: Wood and colored decoupage paper
Hand-Embroidered Domino Game Box With Triangular Pattern	Height: 6 cm, Width: 19 cm Color: Red, Weight: 355 gram Material: Wood and hand-embroidered linin.

4.2.5 Traditional Ceramics, Stone Mosaic, Plastic Mosaic and Pottery

Hand painted ceramic is one of the famous handcraft art in Jordan, Petra and Madaba are the best Jordanian cities that have a busy, markets with plenty of shopping and souvenir shops. However, Madaba is probably best known for its original mosaic designs and handmade spatially in artisan center, Madaba, Jordan. There are different highest quality mosaic crafts made by stones or plastic and clay pottery, including: Mosaic tile art pictures, portraits, vase and jar of clay handmade panted are used for farming in rooftop garden as a cultural values and sustainable local product. The table below shows the traditional ceramics and mosaic in Jordan. See table 11.

Tabel (11) The Traditional Pottery, Ceramics and Mosaic in Jordan

Name of the Local Product and Manufacturer	Product Specification
Traditional Ceramics & Potter hand painted ceramics, & Mosaic Created by Madaba using for vegetation	Geometric floral designs with orange as the primary color.
2 Mosaic stone and plastic Tile created by Nahar Al fonon Madaba Pottery craft store	Size: 50*70cm and Size: 100*70cm
Mosaic Tile created by sammer twal from Nahar Al fonoon co Madaba Pottery,Workshop in university of petra in summer semester 2012	Size: 90X90 cm
Handmade ceramic Candle holders and vases bowls. etc. in different sizes Created by Madaba pottery	This Ceramic is heated above 2k C. degree, with the finest sand combination in the world. https://www.afghanionline.com
Mosaic Plastic plate & vases for planting created by Madaba Pottery craft store	Size: 50*50cm Size: 18X18, highte70cm. Weight: 1.100

Name of the Local Product and Manufacturer	Product Specification
Pottery Lamp Stands created by Petra Pottery	Size: 30 cm H Weight: 1.750
Mosaic Tile for wall created by Nahar Al fonoon co. Madaba, Jordan	Size: 50X70
Clay plate with handmade color created by Madaba Pottery craft store	Size: 50*50cm
Handmade ceramic vases Created by Madaba pottery	This Ceramic is heated above 2k C. degree, with the finest sand combination

4.2.6 Local Jordanian Eco Friendly Environmental Products and Materials by Stones Co.

This company are manufacture high quality products that comply with elite projects standard and massive variety of products, Durable, Eco-friendly, and unique that can be customized to the customers' expectations and needs. Quality is controlled by a team of highly experienced engineers to guarantee that highest standards is achieved. See table 12

Table (12). Local Jordanian Eco Friendly Environmental Products and Materials

Name of the Local Product and Manufacturer	Product Specification
Cement plant beds with wood stands, created by Stones Co.	Square bed size 80*80cm Height: 70cm.
Cement plant beds with hidden lights created by Stones Co	Square bed size 30*30cm Height: 70cm
Cement & stone lighting unites done by stones Co.	With different size like: Square 10*10cm Height: 25cm
Cement wall treatment cladding, created by Stones co.	Cement wall treatment cladding with brick pattern & different color
Brick & stones wall treatment cladding created by Stones Co.	Free size
Metal wall treatments created by Stones Co.	Size for one pice Square 20*20cm

Stones Company offers Handmade Terrazzo Eco-friendly Tiles are the best choice for flooring of rooftop garden in Amman. 20X20cm, also a huge selection of naturally made stone artwork by using Local handicraftsmen produce this special type of art work. Stones focuses on the quality of the natural stones products and offers a variety of choices to ensure the best choice that suits all taste. Handmade concrete art is truly a distinguished line of artwork also handmade Terrazzo Eco-friendly Tiles this product is both eco-friendly and is highly attractive due to its durability. See tables 12, 13

Table (13) List Of Handmade Concrete Art Created By Stones Co.

Name of the Local Product and Manufacturer	Product Specification
Geometric white cement wall treatment cladding created by stone Co	Free size
Cement flying birds mural, created by stone co.	Cement flying birds mural, many pieces with different size
The basalt sculptures done by stones co.	-
Head ball basalt sculpture created by stone Co.	-
Fish Basalt sculpture created by stone Co.	-
Sheep white stoner sculpture created by stone Co.	-
Figure white stoner sculpture created by stone Co.	-
Organic basalt sculpture created by Stone Co.	-
Hors basalt sculpture created by Stone Co.	-

4.2.7 List of international Eco Friendly Environmental product & materials Co.

After the interview with Eng. Omar Jamal Haddad in **Statiah Company** for suitable outdoor furniture he suggests the following marital and furniture that could be used easily in rooftop garden. See table 14:

Table (14) List of International Eco Friendly Environmental Furniture and Fountain with Artistic Products in Amman.

Name of the International Product and Local Agency	Product Specification
Fiber glass furniture with water proof fabric and WPC floor & canopy found in Estatieh Co.	Fiber glass furniture with water proof fabric and WPC floor & canopy
Stone fountain created by Estatieh Co	fountain made by stones
Fiberglass fountain found in Estatieh Co.	Fiberglass fountain made by stones
HPL table top found in Estatieh Co.	90*90cm
Artificial seating found in Estatieh Co.	Size: 40*40cm, Height: 45cm
WPC board found in Estatieh Co	Free size
Up cycle lighting unit made by braided cattail reeds dipped found in Estatieh Co	Size 15*15cm Height: 60cm
WPC with foam found in Estatieh Co	Free size
Straw lighting fetcher found in Estatieh Co	Size:40*40cm Height: 60cm
HPL used for table top found in Estatieh Co	Free size
Artificial fish ceramic mural with different colors found in Estatieh Co	Free size
Reuse wood table found in Estatieh Co	Size 100cm*100cm Height: 40cm

Table (15) List of International Eco Friendly Environmental Materials in Amman

Name of the International Product and Local Agency	Product specification
Fiber glass found in Estatieh Co	Free size
straw cladding found in Estatieh Co	Free size
WPC board found in Estatieh Co	Free size
parquet LVT found in Estatieh Co	Free size
green wall found in Statia Co	Free size

Table (16) List of International Eco Friendlily Environmental Pergolas in Amman

Name of the International Product and Local Agency	Product specification
Steel structure with movable water prof fabric found in Statia Co.	Free size movable pergola
WPC pergola found in MK project management, Tafanunn Co. in Amman	Free size
Polycarp foam eava filler strips by Tafanunn Co. in Amman	Movable pergola
Petra pergola, aluminum with wooden texture in Amman, Jordan	Free size
Afaq pergola	Free size
Industrial Company in Amman, Jordan	

4.3 List of International Eco Friendlily Environmental Lighting Company in Amman.

4.3.1 AVE & Noor Ala Noor Company

AVE s.p.a is an Italian company leading the international scene of the high quality electric and electronic equipment manufacturers. <https://web.facebook.com/avejoofficial/> after the interview with AVE & Noor Al Noor companies (<https://nooralanoor.net>). They suggested the following:

4.3.2 Outdoor Lighting

Outdoor lighting has become more accessible with the development of low-voltage lighting and LED technology, but rooftop lights will need to have a certain IP rating depending on where they will be installed and what they will be used for. Different installations and locations require different IP ratings for outdoor lights to choose the best and safest option.

4.3.3 Standard Garden Lights

There are many standard garden lights such as: path lights, up lights and tree lights, AVE co. suggested the minimum rating of IP44 or higher. The '4' ratings will ensure that lights are protected against splashing and forceful water contact, while also protecting them from all levels of physical contact from objects.

4.3.4 Outdoor Lights Need Different IP Ratings

IP stands for Ingress Protection and all lights and fittings are rated on this feature. The IP rating scale essentially ranks the light source by how effectively it is protected from exterior elements such as liquids or solid objects, and this will dictate where lights can be installed and how much moisture or external force it can safely come into contact with.

IP rating indicated by the initials 'IP' followed by two digits. The first digit indicates the level of protection from solid objects that particular light source has, while the second digit indicates how water-resistant the light is. The higher the digits, the more protection the light source has. Both digits hold relevance for outdoor lighting, so taken consideration the IP rating of the lights, when choosing outdoor lighting.

4.3.5 Motion Detectors for Outdoor Use

Motion detectors for outdoor use provide more efficiency energy, they reliably switch lights on as soon as they detect movement in their detection area. Installation of motion detectors is quick and simple. Brightness threshold (lux), lighting duration and detection area are set via individual potentiometers. With some models it is possible to easily change these settings using a remote control. Jordanian market can improve the usage of outdoor lighting especially in green roof garden, it is available in AVE & Noor Al Noor Company in Amman and online market.

4.4 The Best Way to Waterproof the Roofs in Amman

4.4.1 Insulation Technique Used by Al Bitar Office for Abdoun Roof Park in Amman

Countries under prolonged summers and limited water resources like Jordan, require custom-made design, innovative irrigation techniques, plant species that are particularly heat and drought tolerant. There are several ways depending on location, environment and events, the use of thermal insulation thickness and density suitable to achieve at least the value of thermal transition required in the codes, and be resistant to the external factors of rain and sun, and protection of the insulation from the tear to avoid thermal bridges, we can use also Polyurethane foam for thermal insulation. Also the best way to waterproof the roofs in Amman is by 4-millimeter bitumen membrane fixed by flame. Depends on the economic factor / starting asphalt or asphalt roll and may use the layers of polyurethane and then ceramic. All this depends on the possibility (budget allocated to the project). Insulation technique used by Dr. Yassin Al Isawi, the surface should be cleaned of any dust before applying the insulation, ensure the tendency and drainage of water, isolate all surfaces with hot rolls and isolate the drainage places, protect the waterproofing from weather fluctuations.

Brick, Wooden Beams, Thick Nylon Water Insulation Layer, Gypsum, Rock Wool, were used in the ceiling insulation of Dr. Yassin Al- Isawi rooftop garden in Amman and its very successful way for the small privet rooftop. While the flooring insulation of these roof created by: Concrete, White Insulating Paint from (Dulux), Cement Flooring Tiles, Ceramic Flooring Tiles and Concentrated Concrete Mortar: that made by (Gravel, Cement and Sand)

4.4.2 Insulation Technique Used by Rami Abu Ghoush

Tiles, gravel layer, filter layer, thermal insulation layer, water insulation, slope layer, RC. Concrete, plaster & paint were used in the Eng. Rami Abu Ghoush typical rooftop insulation. See Fig 11. While to harvesting rainwater he used a big roof drain, clamp ring, roofing membrane, insulation cover board with polyisocyanurate rigid foam insulation and strip of fully-adhered air control membrane with expanding foam air seal on the other side he used Oriented strand board (OSB) sheathing with integrated water resistive barrier, existing roof sheathing.

5. Conclusions:

- This research provides a comprehensive guide to the design of building roofs in the city of Amman through several social, environmental and economic aspects.
- This research provides information on the diverse of growing techniques on rooftops, in addition to the types and specifications of space designated for growing plants, their sizes and raw materials.
- A set of factors that should be taken into account when designing roof gardens in the city of Amman, such as weights, the rate of maintenance, and the selection of favorite plants, materials, and conditions for their growth.
- This research provides a design encyclopedia that helps those interested in designing a roof garden and the quality of furniture appropriate for it. It also provides a set of ideas for employing the consumed materials and reusing them in a modern and vital way.
- Socially, the research talks about important areas through which many social environments can be created from spaces for sitting, dining, meeting, fire stoves, and planting areas, in addition to spaces of entertainment and children playing.
- In this paper, there are some examples of methods of displaying plants in geometric and vertical formations of wood and mineral ores
- Researchers and specialists can also identify the appropriate colors for roof gardens and the various color values and methods of displaying and mixing them together to create an atmosphere suitable for the type of garden to be designed
- Through this research, it is possible to identify the types of plants that can be grown, and what are the appropriate growing technique and materials.
- It also contains some examples of artwork accessories, furniture, and materials that designers and consumers need when designing roof gardens
- Determining suitable sustainable local materials for designing the rooftop garden in Amman should be taken into consideration.

6. Recommendations

1. Initiating projects for operating economical green roofs.
2. Selecting the plant species that have adapted to the climate of the city.
3. Proposing projects that attract the private sector for participating and investing in green roofs.
4. Increasing public awareness on the importance of finding solutions for present-day ecological difficulties by using the standers of rooftop gardens.
5. Tracking cooperation between educational and research centers for related studies and researches in rooftop gardens.
6. Determining on suitable sustainable materials for designing the rooftop garden in Amman should be taken in consideration.

7. Recommendations

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- Determining on the suitable sustainable materials for designing the rooftop garden in Amman should be taken in a consideration.

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