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Amman's Land Typology: The Importance of Site Characteristics on the Delivery of Sustainable Buildings

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Abstract: Amman's land typology is characterized by hilly slopes, and this presents challenges and opportunities for architects and designers aiming at delivering sustainable buildings. The research focuses on the importance of any site's given criteria, mainly its slope and topography on the delivery of sustainable buildings. Amman city consists broadly of two main types of buildings, apartment buildings and villas, by studying each type of building with regard to its environmental context on a given site in the city, the research seeks to identify the sustainable variables that site topography delimit or facilitate, using a set of attributes for each building type. The main objective of this research is to highlight the sustainable approach for building on sloped sites throughout the building project life-cycle in general, and to set a sustainability framework for designers during the initial design phase in particular. A number of case studies for both types of buildings are studied and analysed, and conclusions are given based on syntheses of available data from literature review or case analysis. At the end, the research provides a mechanism for the development of guidelines for sustainable and passive viability on preferred buildings orientation in hilly areas with regard to local climatic data.

Key words: Sustainable building, topography, slopped sites, sustainable design guidelines.

1. Introduction

Sustainable development issues and environmental concerns continue to gain interest as demand within Jordan's residential construction industry escalates. Current construction practices adhere to traditional methods of construction, with inherent weaknesses such as high labor costs, negative environmental impact during and after construction, and minimal technological advancement.

Sustainability in buildings and urban design is a regional issue, and quite specifically site-related. In this regards, Amman is a city characterized by its hilly topography. The slopes represent challenging constraints for designers, especially when considering sustainable building measures. Therefore, to construct and maintain a sustainable building is to choose the suitable site and to allocate the building to site correctly. Design decisions in the initial phase would affect the building layout, and eliminate negative impacts associated with negative construction practices.

This research deals with designing and building residential buildings in Amman, the capital of Jordan, with emphasis on two types of building, the apartment building and the villa. The research seeks to outline a framework designing residential buildings, especially, villas and apartment buildings, for designers in the early stage of the design process on the best layout, orientation, and functional layout on sloping sites in Amman city.

2. Methodology

The research depends on descriptive analysis of two different types of residential buildings which are the apartment building and the villa. Sloped site topography is used as a constant value, whereas orientation and building layout on site are used as variables. Each type of building is analyzed using height and number of floors attributes (Table 1).

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Table 1 The research methodology indicators.

Constants	Variables	
Slope	Orientation -north facing -south facing building layout on site	
Building types	Total height (m)	Number of floors
Apartment building	15	4
Villa	7	2

Conclusions are based on studying the optimal design solution for each type of building, when positioned on a south facing slope, and also when positioned on a north facing slope. South cardinal point is used to describe the longest direct component of solar radiation during the day, and especially in the middle of the day.

The incident radiation on the east face in the morning and the west face in the evening is important, but not as that on the south face during the middle of the day. The north face receives no direct component of solar radiation. So the research focuses on analyzing the two building types' layouts on north facing and south facing slopes only.

3. Sustainability

Oxford Dictionary defines sustainability as the ability "to be maintained at a certain rate or level: sustainable economic growth or conserving an ecological balance by avoiding depletion of natural resources: our fundamental commitment to sustainable development".

The most common definition comes from "Our Common Future", also known as the Brundtland Report: "Sustainable development is development that meets the needs of the present generation without compromising the ability of future generations to meet their own needs" [1]. This definition contains three key ideas: development, needs, and future generations. According to Blowers, development should not be confused with growth. Growth is a physical or quantitative expansion of the economic system, while development is a qualitative concept: it is concerned with cultural, social and economic progress. The term "needs" introduces the ideas of distribution of resources: meeting the basic needs of all and extending to all the opportunity to satisfy their aspirations for a better life [1]. Moughtin thinks that the pursuit of a sustainable future for the human race will require the design of effective policies and programmes which directly address the related problems of unsustainable activities and environmental degradation. Any sustainable development at the building and neighborhood level should ensure that the needs of the current users are met without compromising resources or the quality of built environment on the long term.

3.1 Sustainability in Buildings

Buildings account for 40% of global warming emissions [2]. Sustainable building management has received much attention in recent years. Many communities throughout the world are struggling to develop efficient and effective tools for assessing sustainable buildings. However, there is no universal method or tool yet. Sustainable buildings are at the core of any sustainable development, for the sustainable building, the objectives of decreasing both adverse environmental impact and cost are in conflict. In addition, even though both objectives may be satisfied, building management systems may present other problems such as convenience of occupants, flexibility of building, or technical maintenance, which are difficult to quantify as exact assessment data.

In Jordan, sustainability is a new concept still, and many of the very few aiming-to-be sustainable buildings are not quite mature yet. With the first building to gain a LEED (leadership in energy and environmental design) silver certification in 2010 (Fig. 1), Jordan is still long way away from developing a strategy for sustainable building industry.

3.2 How Is Sustainability Measured

To some, sustainability is a matter of numbers, scores and graphs. The ESI (environmental sustainability index) clearly probate a live in an era of numbers. In many realms, decision making has become increasingly data-driven. But the environmental domain has curiously lagged in this regard [3].

On the large scale, there is the ESI in Fig. 2. The 2005 ESI provides a composite profile of national environmental stewardship based on a compilation of 21 indicators that derive from 76 underlying data sets. The ESI offers a tool for shifting pollution control and natural resource management onto firmer analytic underpinnings. In this regard, the heart of the ESI is not the rankings but rather the underlying indicators and variables. By facilitating comparative analysis across national jurisdictions, these metrics provide a mechanism for making environmental management more quantitative, empirically grounded, and systematic [4].

The higher a country's ESI score, the better positioned it is to maintain favorable environmental conditions into the future. The five highest-ranking countries are Finland, Norway, Uruguay, Sweden, and Iceland—all countries that have substantial natural resource endowments and low population density.

Table 2 shows Jordan's position on the 2005 ESI world score. Almost it is two points lower than world median and behind leading countries like Finland. Jordan is a world standard performing country when it comes to energy resources and impacts on the environment. As a developing country, large part of its residential building activity contributes to the country's overall performance on the ESI scale.

Fig. 1 Dutch embassy building—first green building in Amman with LEED silver certificate.

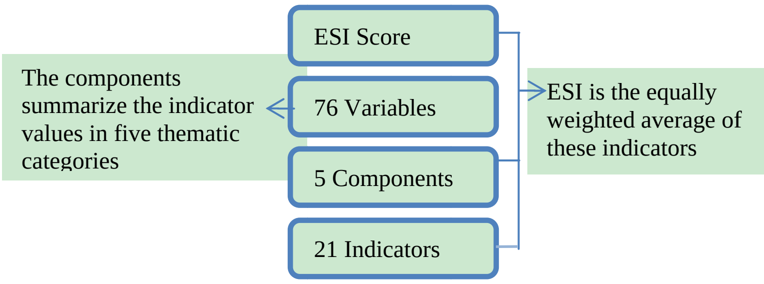

Fig. 2 Constructing the ESI (environmental sustainability index) score [5].

Table 2 Jordan on the (2005) ESI world score [6].

ESI rank	Country name	ESI score
1	Finland	75.1
45	United States	52.9
55	Tunisia	51.8
65	United Kingdom	50.2
75	Indonesia	48.8
83	Oman	47.9
84	Jordan	47.8
136	Saudi Arabia	37.8
World median	-	49.7

There are many tools developed in the field of the performance assessment of the buildings sustainability. Starting from the 1990s, many different evaluation systems and tools of environmental performance assessment for buildings have been developed, as BREEAM (building research establishment environmental assessment method) in the United Kingdom, LEED in the United States (prompted by the US Green Building Council, Energy rating in Denmark, Ecoprofile in Norway, EcoEffect in Sweden, Escale in France, Total Quality in Austria and the DGNB procedures in Germany [4]). These tools are applied for different purposes like combining the energy problems with economic and social concerns, enhancing relationships with urban plans, applying the appraisal procedures in the different stages of the building life-cycle, including the urban context and site features in the evaluation and involving different stakeholders and shareholders (as designers, evaluators, users, investors and researchers) in the evaluation process while promoting the performance approach.

3.3 Sustainability in the Arab World

The Arab world is faced with many urban challenges, in “The Revolving Arab City” [7], it suggests that regional policies (pan-Arab unity) and social security are not a priority anymore. Rather, the private management of public property is becoming more prominent. The creation of private development companies backed by banks or hedge funds, like Al-Abdali in Amman in Fig. 3, Solidere in Beirut, Saphia and BouRegreg in Rabat, Tunis Lake are examples of the new globalised spaces that aims to provide high returns on investments for firms like Sama Dubai, Emaar, Saudi Oger and other national developers (Mawared in Jordan and Caisse de Depot et de Gestion in Morocco) [8].

Arab cities demonstrate multiple layers of development through history. Over long periods of development, land uses have been adapted to suit inhabitants. Conventional urban configurations were based on densities, mixed uses and bottom-up urban growth, reflecting people’s daily needs. Modern Arab cities demand an accelerating increase in transportation mobility pursuant to inappropriate land use distribution. These requirements do not consider the current spatial morphology of the urban fabric, nor its role as a stimulus in successful locations. The differences between traditional and modern extensions for Arab city centres on the basis of sustainable land use location should be re-assessed to evaluate current land use distribution and forecast the success of any future intervention.

The traditional methods of sustainable buildings in traditional Arabic context were mainly focused on techniques that enhanced indoor quality in hot and arid climates. Hassan Fathy was a pioneer in incorporating traditional methods of building into rural areas of Egypt. However, these traditional methods do not solve today’s problems for buildings. Many modern architects have used successful symbolic precedents in modern architecture by means that convey nostalgic reference rather than careful study of these symbols as effective sustainable solutions. The works of Rasem Badran and Abdelwahed Al-Wakeel bear witness to such attempts.

The Arab region geographical typology varies extensively from east to west, and so is the building technology used in every region. In Jordan, a variety of geographical typology is also present, and that also adds to variety of building techniques.

Fig. 3 Al-Abdali represents a new vision of high-rise development in Amman.

3.4 Sustainability in Jordan

The scientific community expects that the world will start to face critical shortages in its supply of fossil fuel in the near future, with the expectation for most oil resources to vanish within the next 50 years [9]. During the past decade, and as a result of the significant increase in the population in Jordan, multi-apartment buildings became the most dominant building format, especially in Amman, the capital. The lack of well-developed passive heating, cooling and energy saving solutions made the reliance on central heating in winter and air conditioners in summer the prominent choice for residents [10]. Jordan is a developing non-oil producing country. Jordan imports 95% of its energy from neighboring countries. In general, large cities in Jordan are comprised of multi apartment buildings, usually about four storeys high. Energy consumption for residential purposes accounted for 18% of the total consumed energy in 1999. By 2009, energy consumption for the residential sector jumped to 30% [11], and is projected to increase if energy saving techniques are not implemented.

3.4.1 The City of Amman

Amman, the capital of Jordan, is experiencing a significant urban and economic growth. The fast increase in population and the growing economic demand for business growth have increased the need for comprehensive planning agendas (Table 3).

Amman as a city has developed 8,000 years ago, due to its suitable climate and availability of water. In the year 1200 B.C., it became the Ammonite's capital, and ever since then it has been in the central attention of many civilizations, until the time it became the capital of Trans-Jordan in 1921 [12]. Amman now is a city of nearly two million inhabitants (Table 4), it is becoming a mega-polis. With the city aspiring to grow and advance—in a world of many environmental concerns like climate change and sustainability—he challenges facing city planners, architects, designers and decision makers are overwhelming. Globally, urban population has increased much faster than rural populations [14]. The ecological footprint of a city can be many times larger than its physical size. Urbanized areas cover 2% of the earth's land surface, but account for 78% of carbon emissions. Similarly 60% of water use and 76% of wood used industrial purposed occur within urban areas [15].

3.4.2 Residential Buildings Types in Amman

Amman's typology is defined by hilly slopes, the topography of the city consists of a series of steep hills and deep and sometimes narrow valleys. Most of the districts of Amman take their names from the hills or Jabals on which they are situated (Fig. 4). Whilst initial development was principally on the upper slopes and crests and the lower slopes of this hill-valley system, the upsurge in urban development over the last 60 years has involved extensive development on the frequently steeper mid-slope locations.

The original site of the city of Amman occupied seven hills or "Jabals" around the Wadi"Ras el Ain" which flows north-east from the plateau towards the River Zarqa basin. The original central part of the city was at an altitude of between 725 and 800 m (Fig. 5).

Table 3 Population and housing census in Jordan in 1994 and 2004 [6].

Census	1994	2004	Increasing (%)
Buildings	504,000	636,000	26.2
Housing units	832,000	1,204,000	44.7
Households	672,000	946,000	40.8
Persons	4,139,000	5,323,000	28.6

Table 4 Population and housing census in the city of Amman compared to the total in Jordan [6].

Governorate	1994				2004			
	No. of buildings	No. of housing units	No. of households	No. of persons	No. of buildings	No. of housing units	No. of households	No. of persons
Amman	144,491	337,071	271,604	1,576,238	182,961	498,085	382,674	1,939,405
Jordan	503,894	831,799	672,472	4,139,458	636,088	1,204,398	945,806	5,100,981
Amman's percentage	29%	41%	40%	38%	29%	41%	40%	38%

Fig. 4 View of the old city—Jabal Amman Hill.

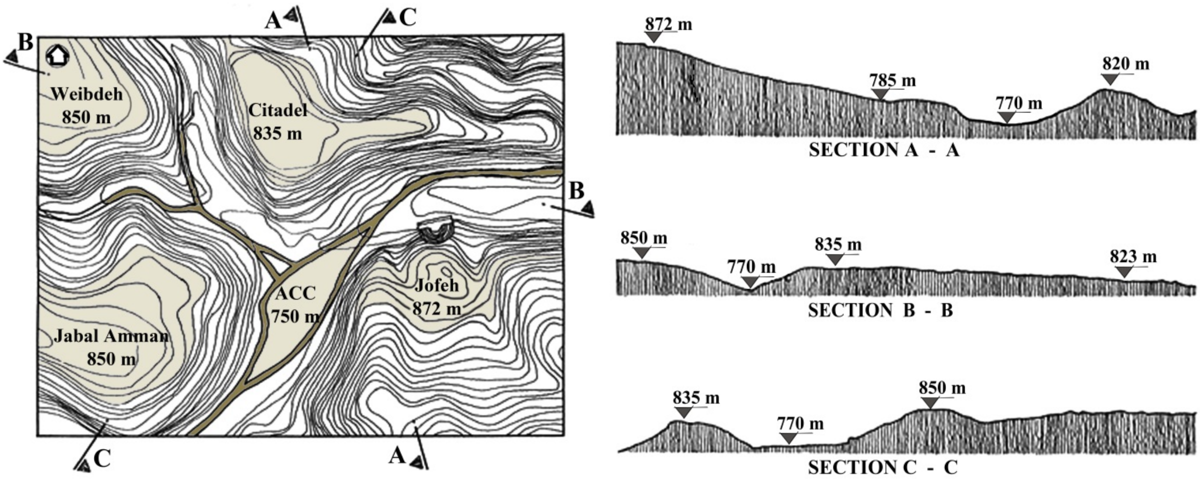

Fig. 5 Topography of ACC (Amman city centre) and surrounding hills or Jabals [13].

Expansion of the city in the past 25 years has resulted in the occupation of some nineteen hills in total with an altitudinal extension to above 875 m. Given all information about Amman typology and geography, it is inevitable that builders and designers in Amman are faced with many challenges. Sustainable building design places significance importance on site, and the relation between building and site that best serves aesthetic, climatic and economical sustainability values. In Amman, construction practices that adhere to traditional methods are obsolete when it comes to serving environmental issues. They are mainly based on wrong design choices at the beginning of the design process. They are also neglecting building orientation and functional layout that contribute to effective passive design.

3.4.2.1 Apartment Buildings

Up to the 1970s, it was very common for people in Amman to build freestanding, one-story, single-family houses. Such houses most often would later be expanded vertically to reach two or three stories. The owner of the house would build these additions for the use of his or her children (usually sons) for when they grow up and have their own families, or to rent out as a source of additional income.

During the late 1970s, the apartment building emerged as a more prominent residential building type in Amman. By the 1990s, it became the predominant building type. In fact, of the 2.18 million square meters of construction permits granted in Jordan during the first four months of this year, 1.8 million square meters were for apartment buildings [16].

The impact of the spread of the apartment building has been tremendous on Amman. It definitely has raised the density of habitation in the city (Fig. 6).

The typical four-story apartment building, which usually includes two apartments on each floor, will have about eight families inhabiting it. Of course, there

Fig. 6 Apartment buildings construction boom in Amman.

are the more luxurious apartment buildings with one apartment per floor, but there are also apartment buildings that have additional living units because of their location on a sloping site. Many apartment occupants, especially in western Amman, have cars, and the construction of each additional apartment building puts further pressure on the movement of traffic in adjacent streets and on the availability of parking spaces. It is also important that with the exception of ground floor apartments, the inhabitants of apartment buildings do not have access to gardens. At the same time, apartment buildings in Amman are too small to support communal open recreational spaces. The problem is exasperated by the fact that Amman still suffers from a shortage of public neighbourhood parks (Fig. 7).

3.4.2.2 Villas

Villas represent the high-end single family dwelling option for buildings in Amman, especially in its western part, they usually comprise one or two floors as shown in Fig. 8.

4. Sustainable Design Criteria

Site selection and building orientation come at top priorities in any sustainability assessment tool. Therefore, the site typology—especially its slope and atural topography is of great importance to the sustainable design decision. If a site is flat, the topography

Fig. 7 Apartment buildings occupying a hill in a north Amani neighborhood.

Fig. 8 A modern villa in western Amman.

may not influence the location and layout of the building, but on a sloping site, the topography is likely to be a significant design factor. The slope of a site or the slope of adjacent sites may affect access to sun and views, it is the need for excavation or fill—as well as increasing costs [17]. Large-scale earthworks increase the risk of erosion by altering soil stability and water run-off patterns, and significantly affect natural biodiversity by removing soils and plants.

The significance criteria lie in the fact that when designing in Amman, designers can not overlook the typology of its most vacant sites. The hilly slopes of Amman are challenging sustainable design by delimiting passive cooling and heating for buildings if the building is not correctly placed on site [18]. Construction works that are contributing to negative environmental impact can be minimized if more site consideration was done during the initial design phase, and the building layout, orientation, etc. were based on more sustainable decisions.

Design should foresee that during construction the amount of site work and disruption is at minimum, the visual impact of the building form on the landscape is not disturbing and the orientation of the building is optimizing the passive heating and cooling of the building [19]. Non-sustainable current construction practices in Amman have visual and cost-related negative impacts on the environment as shown in Fig. 9. The excessive use of retaining walls to solve severe slope cuts is very common as shown in Fig. 10—a practice rendered sustainably nonviable, besides its failure with regards to visual and aesthetic aspects.

Fig. 9 Current practices of building on slopes in a north Amani neighborhood.

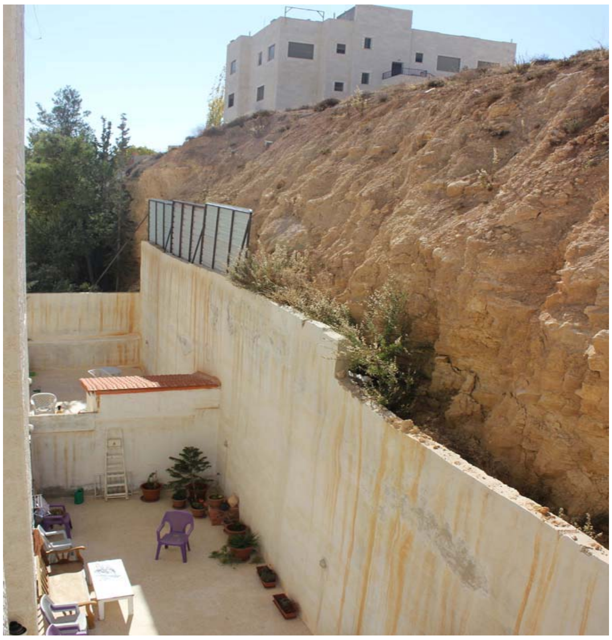

Fig. 10 Retaining walls on severely cut slopes.

5. Conclusions

The amount of solar radiation received by the building envelope depends largely on its orientation.

After analyzing the distribution of solar radiation due to orientation, it is concluded that buildings should be oriented so as to receive maximum solar radiation in the cold weather and should be planned in such a way that benefit is obtained from shaded indoor and outdoor living areas when the weather is hot, by means of overhangs and shading devices, where the high angle of the sun enables the shading overhangs to cast shadows on the south elevations.

A preferred building position on a slope is the terraced option (Figs. 11 and 12), as this minimizes the need for high retaining walls, and provides terraces and green roofs, a beneficial option for multi-family housing units and apartment buildings. In the two case scenarios—the apartment buildings with four floors, and the villa with two floors, the terraces can be of great benefit when the slope is south facing, as this provides exposure to a generous amount of solar radiation during the winter months. If green roofs are introduced above terraces, this will enhance passive building performance when it comes to minimizing heat loss in the cold winter months, and reducing solar heat gain in hot weather.

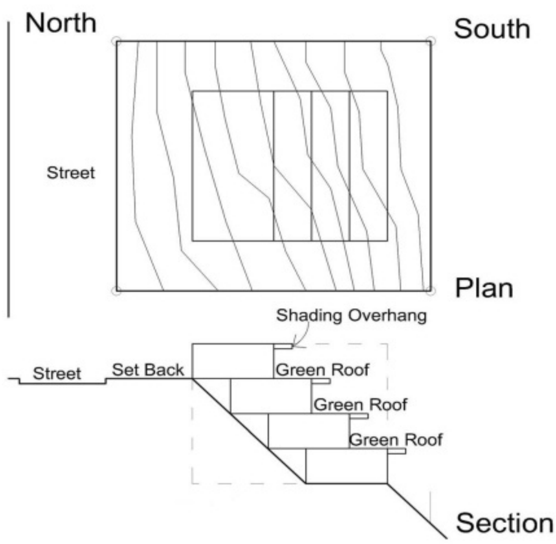

Fig. 11 Suggested apartment buildings layout on a south facing slope.

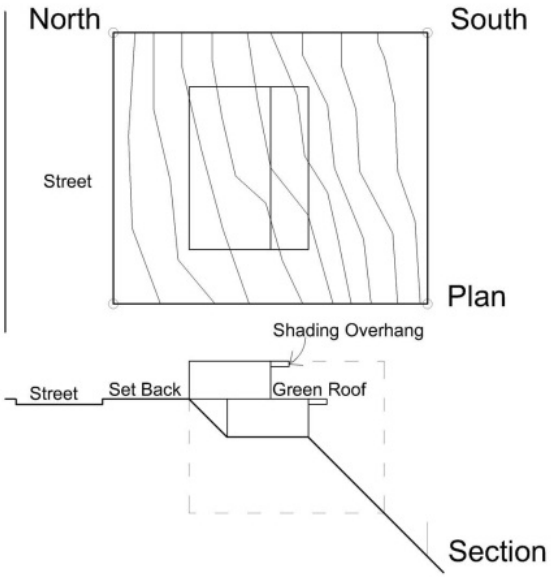

Fig. 12 Suggested layout for villas on a south facing slope.

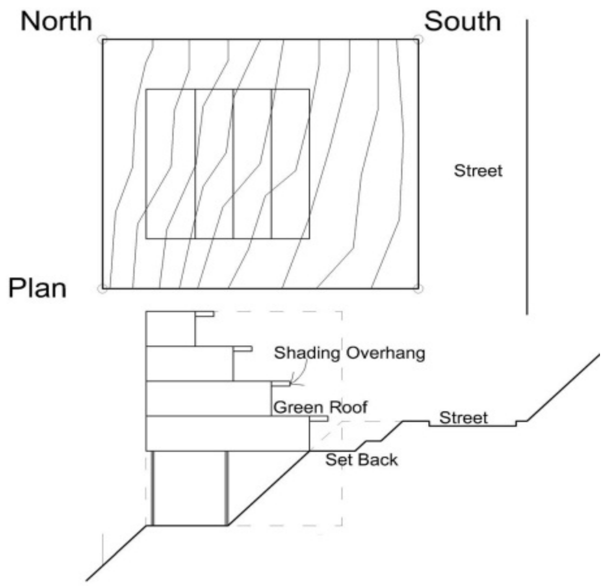

Fig. 13 Suggested apartment buildings layout on a north facing slope.

When the building is positioned on a north facing slope, the building will lose the benefit of significant solar energy during the day, and thus will lose passive heating in the winter months and natural light during the day.

In a city like Amman, with relatively cold winter months, this can be solved by elevating the building in a way that enables maximum exposure to solar radiation from the south side. This can also be achieved by increasing the setback distance to minimize shadows cast on the south elevation by other buildings. Terracing the building towards the south will work on increasing the areas of surfaces receiving southern solar radiation and thus gaining more heat in the winter months (Figs. 13 and 14).

An important conclusion belongs to the factor of the compactness of the building, because when dealing with small single-family villas, where the heat loss through the external surfaces if compared with the heated area of the building, in general, is higher than multi-story apartment buildings. The criteria for the multi-family apartment building needs slightly lower design thermodynamic parameters than for the single-family residential villa in the same climatic conditions. This is explained by the fact that a multi-family apartment building is a more compact construction type, where the heat loss through the external envelope is less in relation to the heated area. So a terracing option will add green roofs and make an apartment building with an average of four floors an ideal passive solution when all variables and passive design solutions are considered.

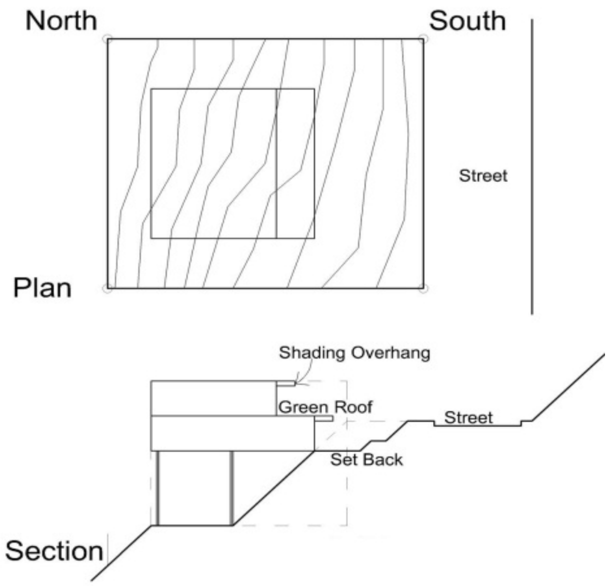

Fig. 14 Suggested layout for villas on a north facing slope.

References

[1] United Nations, World Population in 2300, Princeton Architectural Press, New York, 2004.

[2] G. Brand, Green Buildings for Cool Cities, Oxford University Press, Oxford, New York, 2010.

[3] D.C. Esty, Environmental Performance Measurement: The Global 2001-2002 Report, in: D.C. Esty, P. Cornelius (Eds.), Oxford University Press, New York, 2002.

[4] S. Mattia, A. Oppio, M. Ghellere, A. Pandolfi, A Multidimensional and Participatory Approach to the Building Performance Assessment: Addressing the SBTool Model to Social Multi-Criteria Decision Analysis, CSAAR Publications, Amman, 2010.

[5] ESI (environmental sustainability index), Yale Centre for Environmental Law and Policy, Conn., New Haven, 2005.

[6] Population and Housing Census 2004, Department of Statistics, Amman, Jordan, 2004.

[7] R. Daher, Amman: Disguised Geneology, Recent Urban Structuring and Neo-Liberal Threats, in: Y. Elsheshtawy (Ed.), The Evolving Arab City: Tradition, Modernity and Urban Development, Routledge, London, 2009.

[8] P.A. Barthel, Arab Mega-Projects: Between the Dubai Effect, Global Crisis, Social Mobilisation and a Sustainable Shift, Built Environment 36 (2) (2010) 133-145.

[9] T. Canty, World Energy Needs and Fossil Fuel Reserves, AOSC 434/658R and CHEM 434/678A, Kuwait City, 2009.

[10] N. Beithou, Y. Abdellatif, M. Al-Taani, M.A. Hilal, Proposed Energy Saving Techniques for Multi-Apartment Buildings in Jordan, IASKS Publications, Jordan, 2010.

[11] UN-Habitat (United Nations Human Settlements Programme), Planning Sustainable Cities—Global Report on Human Settlements, Earthscan, London, 2009.

[12] A.R. Bakij, Amman: A History with Pictures, Greater Amman Municipality Publications, Amman, Jordan, 2002.

[13] Y. Rajjal, Urban space and movement patterns, study of Amman city center, Master's Thesis, University of Jordan, Amman, Jordan, 1989.

[14] UN-Habitat (United Nations Human Settlements Programme), State of the World's Cities 2008/2009—Harmonious Cities, Earthscan, London, 2008.

[15] L.R. Brown, Eco-Economy: Building an Economy for the Earth, W. W. Norton & Company, New York, 2001.

[16] A. Al-Salaymeh, A general model for the prediction of global daily solar radiation on horizontal surfaces for Amman city, EJER (Emirates Journal for Engineering Research) 11 (1) (2006) 49-56.

[17] M. Breheny, Sustainable Development and Urban Form, Pion Limited, London, 1992.

[18] D. Farr, Sustainable Urbanism: Urban Design with Nature, John Wiley, Hoboken, New Jersey, 2008.

[19] J. Grant, Planning the Good Community, Routledge, New York, 2006.