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Sustainable Urban Development by Expanding the Green Roofs to Improve the Urban Environment Quality (Case Study: Karaj, the fourth most populous City in Iran)

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1 ABSTRACT

Global climate change, which is also occasionally a result of urbanization, has brought the relationship between humans and the environment to a serious discussion. Humans have eroded the balance of nature because of incorrect use and the increasing rate of energy consumption and energy resource constraints. In addition to the environmental pollution and waste of human capitals, there is not only the danger of environment destruction, but also the future of human life is at risk.

Iran is not spared from this global change and even because of various issues including e.g. geographical factors (a large part of Iran is located in hot and dry desert climate), energy consumption patterns, fossil fuel resources, is grappling with climatic and environmental problems more than other countries. Growth in annual consumption of energy has led the need to adherence to the goals of sustainable urban development to be more and more recognizable.

Karaj city which is a metropolis in Iran and rapidly growing, has also the same situation. Karaj is the center of Alborz- the 31st province of Iran - and is located 34 kilometers west of Tehran. Unprecedented increase in the population of the city- Karaj is the forth populous city in Iran with a population of more than 2,000,000 people- and other urban issues today, have been followed by many problems including environmental ones such as heavy traffic, noise and air pollution. Therefore, it seems to be a good solution for these problems helping Karaj to achieve the goals of sustainable urban development by rooftop greenin. Green roofs can have major environmental impacts on contemporary cities due to improve and sustain the quality of urban environment. That is why the purpose of this project is the introduction of green roofs as a strategy for sustainable urban development particularly in the city of Karaj.

The project has been started to be processed. The environmental sustainability of Karaj should be assessed with the environmental and consumption data like e. g. annual energy consumption, air pollution, per-capita green space. Five regions have been chosen in different city areas based on the relation between built area volumes (buildings) and green spaces (each of them is one square kilometer at least). Based on this fact that climatic situations, framework shape and city components are the most important factors, which affect the performance of green roofs in an area, these areas have been simulated by the numeric simulation model Envimet. Afterwards, according to obtained statistics, there would be a particular program (Karaj environmental strategic plan) to make use of green roofs. This program will function based on the factors: regional climate and micro-climates, annual rainfall, average solar radiation energy, drought periods, frost days and wind direction as well as wind speed. In the end, specific criteria for future construction of green roofs and existing buildings would be suggested and implemented in a sample neighborhood.

Keywords: green roofs, urbanisation, sustainable urban development, Karaj city in Iran, Envimet

2 INTRODUCTION

The process of urbanization in today's world and a rapid global population growth, the technology advances, the exploitation of the natural environment on a large scale, also changes in consumption and life patterns of societies, have caused an environmental degradation that has disrupted the balance between humans, animals, plants (living environment in general) and the surrounding environment. This development has put today's human in a very difficult situation (Nejati Hoseini, 2004).

Urbanization and urban development since the Industrial Revolution caused the appearance of mega cities with plentiful problems of environmental and urban issues. It has been a long time that adverse effects of urban lifestyle have brought major problems for human and environment. The impacts not only have endangered the life of today's flora, fauna and human, but also will be followed by a very bad future for the next generations.

Many big cities around the world have got major problems. Poverty, unemployment, rapid urban growth, population settlements, the problem of marginalization and energy consumption are issues, which jeopardize their sustainability. In these circumstances, and given that the world's fossil energy resources are limited and quickly running out, the city pollutions have caused the environment to destroy. Therefore, it is enevitable to solve this problem quickly and to save the city and save humanity from the consequences of environmental degradation respectively.

Sustainable development could be the carrier of many human wishes and dreams and establish a proper relationship between human and nature. Also it is thought, that as a new paradigm, many of the global strategies of the 21st century would be planned in the framework of this concept. Thus, sustainable development in recent years, has proposed itself not only as one of the main challenges, but also as a focal point for debate on many of the issues raised during the chaos of the world.

3 SUSTAINABILITY AND SUSTAINABLE DEVELOPMENT

The concept of sustainability has been an integral part of development work since the late 1980s. Defining sustainability is consequently not simple, as it is a broad and deep concept, that depends on many factors (Sustainable Cities International, 2012). In order to provide a basis for understanding sustainability, it is important to understand the most accepted definition of sustainable development, which resulted from the work of the World Conference on Environment and Development in 1987. They published their report entitled, 'Our Common Future' (WCED, 1987), often known as the 'Brundtland Report', after its chair, the then Prime Minister of Norway, Gro Harlem Brundtland (Elliott, 2006).

The Brundtland commission defines sustainable development as a development "that meets the needs of the present without compromising the abiliy of future generations to meet their own needs" (Sustainable Cities International, 2012).

Identified by the World Commission on Environment and Development (WCED), there are the following critical objectives and necessary conditions for sustainable development:

Critical objectives

- reviving growth,
- changing the quality of growth,
- meeting essential needs for jobs, food, energy, water and sanitation,
- ensuring a sustainable level of population,
- conserving and enhancing the resource base,
- reorientating technology and managing risk and
- merging environment and economics in decision-making.

Pursuit of sustainable development requires

- a political system that secures effective citizen participation in decision-making,
- an economic system that provides for solutions for the tensions arising from disharmonious development,
- a production system that respects the obligation to preserve the ecological base for development,
- a technological system that fosters sustainable patterns of trade and finance,
- an international system that fosters sustainable patterns of trade and finance and
- an administrative system that is flexible and has the capacity for self-correction (WCED, 1987).

3.1 Urban development and sustainable urban development

Urban development as a space concept, can be defined as changes in land use and density levels, to meet the needs of residents in the areas of housing, transport, leisure, food and etc. Such a development would be sustainable when once over time, a city would be environmentally habitable (clear weather, safe drinking water, land, surface and groundwater free from pollution), economically viable (urban economy should be

coordinated with technical and industrial changes to maintain its basic businesses and provide appropriate and affordable housing for its residents) and socially associated (land use patterns should be social cohesion and a sense of citizenship that lead humans to obtain a fair income, provide adequate shelter and devote their time and effort to protect the city image).

To date, progress towards sustainability has predominantly been investigated at the national level through comparative analysis of nations by the UN Commission on Sustainable Development (CSD). However with the deadline for the Millenium Development Goals (MDGs) approaching, focus is increasing on cities and their capacity to meet sustainability targets. Furthermore it has become evident that irrespective of the MDGs the demand for solutions to climate change, natural resource depletion and environmental degradation is pressing, especially as the population of the world increases and many people find themselves living in urban centers (Sustainable Cities International, 2012).

3.1.1 Sustainable Urban Development and Green Roofs

As urban populations grows, the dilemma of how to create and sustain a healthy urban ecosystem is becoming more prominent. The urban heat island effect, stormwater runoff, air pollution, and the loss of tree canopy, green spaces, and wildlife habitats are all issues affecting urban sustainability. Green roofs, which are especially designed landscapes atop buildings, can provide solutions to many of these problems, as well as enhance the quality of life for urban residents.

Development and equitable distribution of urban green spaces in the neighborhoods, especially in city centers, in a manner that is commensurate with urban construction, is considered as one of the major challenges of contemporary metropolises. Since urban green spaces often appear without direct economic values, the development of constructions, which will in short term have greater benefit in local government and public sector investment, has caused an increase in the amount of land used for the short-term economic benefits and the development of urban green spaces in comparison to other investments, gets less financial support. The problem in both, developed and developing countries, for the reason that urban drivers pay special attention to economic benefits in the short term, is more highlighted. Obligations of developed countries to environmental agreements and charters, as well as public pressure that have a more informed perspective on environmental issues, is the etiology of impetus to identify new solutions to the development of urban green spaces.

Using green roofs is one of the new approaches of architecture and urbanization, based on the concepts of sustainable development, which can be used to increase the per capita green space, improving the quality of the environment and sustainable urban development (Vice Presidency for Strategic Planning and Supervision of Iran, 2010).

4 WHAT IS A GREEN ROOF?

The National Roofing Contractors Association (NRCA) defines green roofs as “plantings/landscaping installed above a waterproof sub¬strate at any building level that is separated from the ground beneath it by a man-made structure”. In other words, green roofs are made of several layers of different materials, which are placed directly on the structure of the rooftop. These layers allow particular plants to grow on the roofs. The typical layers of green roofs systems are:

- a waterproof membrane to prevent leaks,
- a root barrier to prevent plant roots from caus¬ing structural damage,
- a layer of insulation,
- a drainage system,
- the growing medium and
- plants.

4.1 Different types of grenn roofs

Green roofs are divided into three groups depending on the depth of the planting layer, the type of plants and the amount of facilities needed: extensive green roofs, intensive green roofs and semi-intensive green roofs.

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Extensive green roofs are lightweight with a shallow layer of growing substrate (< 6″ depth), requiring minimal maintenance. They generally have lower water requirements and use small, low-growing plant species, particularly succulents. Intensive green roofs are generally heavier, with a deeper layer of growing substrate (> 6″), and support a wider variety of plant types. Because of supporting a heavier weight, they are readily accessed by people. Intensive green roofs need more irrigation and maintenance compared to extensive roofs. They are highly engineered landscapes, often built directly on structures with considerable weight load capacity, such as car parks. Roof gardens or podium roofs are terms also used to describe this types of green roof. Roof gardens are used particularly for sites where less space is dedicated to the vegetation and growing substrate and more to hard infrastructure such as decking (Growing Green Guide, 2014). The third type of green roof is in fact a combination of extensive and intensive green roofs, which is called semi-intensive green roofs. Recently, the pre-prepared models have entered the market of this technology, which can be installed on any roof and balcony without the need for infrastructure. These pre-fabricated parts with varied vegetation cover and pre-planted plants from trees to shrubs, are available (Vice Presidency for Strategic Planning and Supervision of Iran, 2010).

4.2 The history of green roofs

The idea of covering buildings with soil in order to create a temperature buffer, or to camouflage them or protect them from splinters, is basically as old as the act of building itself. Another reason for covering roofs with a layer of soil was to protect the roof seal in areas endangered by fire and heat (Appl, 2009). Roof gardens, the precursors of contemporary green roofs, have ancient roots. The earliest documented roof gardens were the hanging gardens of Semiramis in what is now Syria, considered one of the seven wonders of the ancient world (Obendorfer et al., 2007).

The modern green roof originated at the turn of the 20th century in Germany. 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 fireretardant structures (Köhler, 2003).

In the 1970s, growing environmental concern, especially in urban areas, created opportunities to introduce progressive environmental thought, policy, and technology in Germany. Green-roof technology was quickly embraced because of its broad-ranging environmental benefits. Interdisciplinary research led to technical guidelines, the first volume of which was published in 1982 by the Landscape, Research, Development and Construction Society. Many German cities have introduced incentive programs to promote green-roof technology and improve environmental standards. Such legal underpinnings of green-roof construction have had a major effect on the widespread implementation and success of green-roof technology throughout Germany. The market for sloped green roofs is also developing rapidly, and accessible green roofs have become a driving force in neighborhood revitalization (Obendorfer et al., 2007).

5 RELATED ELEMENTS OF SUSTAINABLE DEVELOPMENT AND GREEN ROOF SYSTEMS

Sustainable development has three principals including environmental sustainability, economic sustainability and social sustainability. Green roofs as a system that has a key role in the sustainable development of cities have advantages in all three pillars of sustainable urban development.

5.1 Economic advantages

Despite the initial cost of installation and running, green roofs include fee returns in the duration of use and operation. The most important economic benefits of green roofs are:

- reduction in heat exchange and increasing the efficiency of air conditioning units (functioning as a thermal insulator),
- increase the efficiency of solar panels,
- increase durability and longevity of materials,
- protection against fire,
- increase shelf spaces in buildings and
- sound insulation.

5.2 Environmental advantages

Green roofs are also known as living roofs. Environmentally, green roofs, if widely implemented on a massive scale in the urban space, can reduce pollution by absorbing carbon dioxide and producing oxygen. The main environmental benefits of green roofs are:

- Flowing water management
- Reduction in the heat island effect
- Air cleaning
- Restoration animal habitats to urban areas (Raheb, 2013).

5.3 Social advantages

Humans and human societies, are the main axis of sustainable development. The goal of sustainable development is comprehensive development and it will not be possible without social development. In general, sustainable development is to achieve a vibrant and sustainable community and it would not be possible without the environment protection. Beautifying the urban environment is the most important social benefit of green roofs, which is involved in promoting the urban landscape that is visible by pedestrians and residents in height. Rising the number of floors of a building, the roof would be considered as the fifth facade of the building and the use of green roofs as communal spaces, increases social interaction among residents in pleasant and desirable environment (Keshtkar Ghalati, 2010).

6 RECOGNIZING THE CONTEXT OF THE PROJECT

Karaj city is the center of Alborz - the 31st province of Iran - and is located 34 kilometers west of Tehran. Karaj with about 2,000,000 inhabitants and 164 square kilometers, is located in the southern slopes of Alborz Mountains. The geographical location of the city, which is near to the capital city and situated along the connecting highway of the west and south, good summer weather, natural tourist attractions and the Karaj-Chalus road, which is the most beautiful road in Iran, have turned Karaj into a metropolis. Immigrants to the city would be estimated much higher due to the low price of land and housing in comparison to Tehran. Actually, around Karaj, satellite towns exist and similarly a large number of manufacturing industrial towns.


Fig. 1: An overview of Karaj, Fig. 2: Karaj dam and river

7 GREEN ROOF TECHNOLOGY IN IRAN

Difficult weather conditions at a wide range of the country, Iranians were always looking for ways to expand green and blue infrastructure. This development has been considered as sustainable life values in the country. Creating beautiful gardens in the desert, green courtyards, duging aqueducts, etc. are examples of Iranian's efforts to spread prosperity in facts of difficult conditions (Raheb, 2013).

Given the historical background of mud brick architecture, roofs of houses and villages traditionally and historically were covered with moss, lichens and herbaceous plants in different parts of the country such as Azerbaijan, Gilan and Mazandaran. A very good example are the houses of Masoole village, where the lower house roofs act as the upper house yards.

With the increasing problems of the modern world, sustainable systems became the priority policies of developed countries. Developing countries like Iran are now following the implementation of these policies in order to solve various problems of cultural, social and environmental dimension with considering economic consequences.

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Green roofs are not a new issue in Iran. Using green roofs and green walls technology could be a solution to increase the per capita green space and partial solution to some environmental problems caused by the uncontrolled growth and spread of major cities in the country. The growth and development of green roofs in Iran, need to provide a basic introduction in which this technology can grow and develop. Unfortunately, the use of green roofs despite its considerable potential functions, more remains as an idea in urban management. In spite of the fact that most of the regions in Iran are located in hot and dry areas, green roof technology cannot be developed in Iran the same way as in rainy regions. Several countries with similar conditions to Iran and even much harder climatic situation have used special measurements to implement green roof technology to make use of its benefits. So the first step is to analyze the current situation and urban potentials and obligatory directions (Henninger et al., 2015).

8 NECCESITY FOR THE PROJECT

Karaj population growth has led to many environmental problems. Transferring from garden city to metropolis, building density increases and the lack of green space have lowered the quality of life in this city. An increase in traffic density, air pollution, air temperature and an unsuitable urban perspective are the most essential issues and problems of living in Karaj. Urban development has destroyed the possibility of green space growth. This issue in addition generating the above mentioned problems, has also minimized the possibility of precipitation percolation on land and caused difficulty for runoff inhibition in the city.

Construction developments and an increase of building density have caused rising the horizontal and vertical surfaces. This process not only reduces the surface area of rain and snow percolation, but also decreases the adverse reflection of sunlight. These surfaces, if properly managed, could provide a significant potential for the development of green spaces. Green roofs and walls may expand as an effective way to solve the environmental problems of big cities in the world.

Due to the mentioned problems and high value of land in Karaj metropolis and consequently, the vertical growth of the city, the low surface area of green spaces per capita according to the international standards of urban green spaces and finally unequal distribution in the neighborhood using green roof technology on the rooftops of Karaj seems a good option.

Following factors are reasons to consider green roofs as an effective way to reduce pollution and to the effects of dense urbanization in Karaj:

- stormwater runoff affecting drinking water and the habitat in Karaj river,
- increased impervious surface areas and the urban heat island effect,
- energy demand in commercial and residential buildings such as shopping centers,
- deteriorating air quality,
- the lack of green space for social and recreational use and
- increasing the loss of biodiversity.

9 RESEARCH OBJECTIVES

According to Section 19 of the National Building Regulations of Iran concerning energy saving and the benefits of green roofs on energy saving, green roofs can also act in line with national building policies. Also, a central issue called green government has been set (Fourth Development Plan of Iran), and the energy savings and environmental cultures have been proposed, making the rooftops green in Karaj can serve to achieve the goals of green government.

To determine the role of green roofs improving the urban environment in Karaj the aim of the project is:

- Providing a general overview of benefits associated with green rooftops (s. Tab. 1),
- identifying the problems, which green roofs can reduce,
- identifying the role of green roofs in providing community space and aesthetics and
- identifying the barriers to implementation of green roofs in Karaj.

Ecology	• maintaining biodiversity and habitat creation • improving the ecological – biological urban quality
Climate	• adjust the heat island effect • adjusting cooling effects
Urban environment quality	• improving air quality • reducing noise • reducing the runoff volume from heavy rainfall • increasing the water quality and preventing from pollution • reducing the effects of electromagnetic radiation
Economic- cultural	• extending the operation life period of the roof insulator • recreation and health • energy saving (insulating cover in winter)

Table 1: Green rooftops benefits

10 PROJECT ASSUMPTIONS

Making the rooftops green in Karaj needs research and pilot projects to adapt green technologies at the national level. Because of the location of Karaj (hot and dry region), it is necessary to consider solutions to preserve green roofs. Research on the types of plants that can be grown on the roofs of Karaj, how to transfer this technology, studies related to green roof design by municipalities, regulations/ the experience of countries similar to Karaj conditions in terms of climate, cultural as well as economic situation, are issues that must be addressed.

11 OBSTACLES TO THE DEVELOPMENT OF GREEN ROOF TECHNOLOGY

In addition to all the extensive environmental benefits of green roofs there are high administrative costs of installation, watering and maintenance, old buildings with unknown structural capacity for green roofs, and limited incentives for builders and developers, that deny this new technology to find its rightful place in contemporary sustainable cities.

Main criteria of green roofs underdevelopment in Iran include: cultural dimensions, management dimensions, investment dimensions, scientific and technical infrastructure dimensions, geographic dimensions, and legal dimensions.

12 SUGGESTED SOLUTIONS

Roofs in previous century would be green because of functional advantages and nowadays, they are green because of environmental benefits. By combining these two ideas and adding many other social benefits resulting from the application of these spaces, local governments can take steps toward sustainable development of green roofs and sustainable urban management. This application can be coordinated with the use of the building. If it is a government building, the roof space can be used to provide needs of the neighborhood or in larger scale, the city's needs.

13 ORGANIZATION AND METHODOLOGY OF THE PROJECT

Given the above background in the case of green roofs role in sustainable urban development and eliminating environmental problems especially in Karaj city and based on this fact that climatic situations, framework shape and city components are the most important factors, which affect the performance of green roofs in an area, first in this project the environmental sustainability of Karaj should be assessed with the environmental and consumption data like e.g. annual energy consumption, air pollution and per-capita green space. The indicators of sustainable urban development and environmental problems in the 12 district areas of Karaj municipality have been discussed and according to the results and based on the relation between built area volumes (buildings) and green spaces, five regions have been chosen in different city areas, each at least one square kilometer. These areas have been simulated by the numeric simulation model Envimet. Afterwards, according to obtained statistics, there would be a particular program (Karaj environmental strategic plan) to make use of green roofs. This program will function based on the factors:

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- regional climate and micro-climates,
- annual rainfall,
- average solar radiation energy,
- drought periods,
- frost days and
- wind direction as well as wind speed.

Based on the proposed program, specific criteria for construction of green roofs on future and existing buildings would be suggested and finally according to the proposed regulations, green roof design would be implemented in a sample neighborhood. That means, that the chosen region will be designed based on those regulations.

14 CONCLUSION

Karaj city not long ago, due to the good weather and the existence of water resources such as the Karaj River, was a beautiful green garden city with old and countless trees. In 1961, with a population of 14,000 people, the city was in fact a small town with a simple infrastructure, but tailored to it's needs. Suddenly and explosively, it became a much dense city. Over the past 40 years, with the influx of population from all over Iran, now Karaj has a population of about 2,000,000 people still rising and expecting to reach 2,200,000 inhabitants in 2025. The urban crisis following the physical development of the city occured, gradually the gardens were destroyed and replaced with residential areas and roads. This green city grew gradually gray.

According to Kennedy et al. (2007), a sustainable city can only be one for which the inflow of material and energy resources, and the disposal of wastes, do not exceed the capacity of the city's surrounding environment. In other words, for achieving environmental sustainability urban consumption must match to be below what the natural environment _ such as forests, soil and occean_ can provide, and the resulting pollutants must not overwhelm the environment's ability to provide resources to humans and other members of the ecosystem.

Environmental pollutions such as air pollution in Karaj, as in other major cities, is caused by several factors such as urban population growth and urban development, the increase in the number of vehicles and the industrial development. So Karaj metropolis has become the eight most air polluted city in Iran, which itself proves that Karaj is not environmentally sustainable.

Considering the numerous environmental pollutions, the excessive development of the city and the high price of land in Karaj, it seems that with the development of green roofs, it would be possible to solve the problem of environmental pollution in Karaj by increasing the per capita green space in the city and take a step toward sustainable urban development, which is an objective of this project.

15 REFERENCES

ALPOPI, Christina: Sustainable Development Principles. In: Theoretical and Empirical Researches in Urban Management, Vol. 2, Issue 3, pp. 1-9. Bucharest, 2007.

ANSEL, Wolfgang & APPL, Roland: Future oriented and sustainable green roofs in Germany. In: Greening rooftops for sustainable communities conference. Portland, 2004.

ANSEL, Wolfgang & APPL, Roland: Green Roofs – Bringing Nature Back to Town. In: Intenational Green Roof Congress, Berlin, 2009.

APPL, Ronald: Past – Pesent – Future: Green Roof Techniques in Changing Times. In: Green Roofs – Bringing Nature Back to Town, International Green Roof Congress, Berlin, 2009.

DEL BARRIO, Elena P.: Analysis of the green roofs cooling potential in green roofs, energy and buildings. Chicago, 1998.

ELLIOTT, Jennifer A.: An introduction to sustainable development, Third edition. Abingdon, 2006.

GORSE, G.L.: Genoese Renaissance Villas: A Typological Introduction. In: The Journal of Garden History, Vol. 3, Issue 4, pp. 255-280. Philadelphia, 1983.

GROWING GREEN GUIDE: A Guide to Green roofs, walls and facades, in Melbourne and Victoria, Australia. Melbourne, 2014.

HEIDARI, Jahangir: Basics and concepts of sustainable development and sustainable urban development. Tehran, 2014.

HEJAZI, Rezvan: Basics of Sustainable Development with Emphasis on Urban Environment. Tehran, 2015.

HENNINGER, S., Elmarsafawy, H. & K. Tobias: Bahrain Regains Greenery. In: Journal of Environmental Protection, Vol. 6, pp. 929-934, 2015

KENNEDY, Christopher- CUDDIHY, John and ENGEL-YAN, Joshua: The Changing Metabolism of Cities. In: Journal of Industrial Ecology, Vol. 11, Issue 2, pp. 43-59, Yale Univesity, New Haven, 2007.

KESHTKAR GHALATI, Ahmadreza: Green roof system development based on sustainable development criteria in Iran. In: Hoviatshahr, Vol. 4, Issue 6, pp. 15-28. Tehran, 2010.

KÖHLER, Manfred: Plant survival research and biodiversity: Lessons from Europe. In: First Annual Greening Rooftops for Sustainable Communities Conference, Awards and Trade Show, Chicago, 2003.

LUCKETT, Kelly: Green Roof Construction and Maintenance. New York, 2009.

NEJATI HOSEINI, Mahmood: Urban planning & management: theoretical & practical issues. Tehran, 2002.

NOHORLI, Davoud & ABDULLAHI, Mehdi & VALIBEIGI, Mojtaba: The study of effective factors in limiting the development of green roofs in Iran based on hierarchical analysis. In: Journal of environmental studies, Vol. 37, Issue 60, pp.89-98. Tehran, 2012.

OBERNDORFER, Erica- LUNDHOLM, Jeremy- BASS, Brad- COFFMAN, Reid R.- DOSHI Hitesh- DUNNETT, Nigel- GAFFIN, Stuart- KÖHLER, Manfred- K. Y. LIU, Karen and ROWE, Bradley: Green Roofs as Urban Ecosystems: Ecological Structures, Functions, and Services. In: BioScience, Vol. 57, Issue 10, pp. 823-833. Oxford, 2007.

RAHEB, Ghazal: Green roofs and its functions, Center of Way, Housing and Urban Development studies, Tehran, 2013.

SHIRAZI, M. Reza: Contemporary Architecture and Urbanism in Iran. Basel, 2018.

SUSTAINABLE CITIES INTERNATIONAL: Indicators for Sustainability, How cities are monitoring and evaluationg their success. Canadian International Development Agency, Canada, 2012.

SUTIC, Nada: How green roofs can improve the urban environment in Uptown Waterloo. Waterloo, 2003.

THURING, Christine E.: Ecological dynamics on old extensive green roofs: vegetation and substrates > twenty years since installation. A thesis submitted in partial fulfilment of the requirements for the degree of Doctor of Philosophy, The University of Sheffield, 2015.

UNITED NATIONS HUMAN SETTLEMENTS PROGRAMME (UN-HABITAT), WORLD CITIES REPORT 2016: Urbanization and Development: Emerging Futures. Kenya, 2016.

VICE PRESIDENCY FOR STRATEGIC PLANNING AND SUPERVISION, Islamic Republic of Iran: Criteria for Urban Landscape Design (First Review). Office of Deputy for Strategic Supervision, Bureau of Technical Execution System, Tehran, 2010.

WENG CHAN, Ngai- IMURA, Hidefumi- NAKAMURA, Akihiro- AO, Masazumi: Sustainable Urban Development Textbook. Penang, 2016.

WERTHMANN, Christian: Green Roof- A Case Study: Michael Van Valkenburgh's Associates Design for the Headquarters of the American Society of Landscape Architects, New York, 2007.

WORLD COMMISSION ON ENVIRONMENT AND DEVELOPMENT: Our Common Future. Oxford, 1987.

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