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Effect of climate change on public spaces and architectural solutions for public areas

Az éghajlatváltozás hatása a közterületekre és a közterületek építészeti megoldásaira

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## 1. Abstract

We have recently experienced hot summers all over the world due to climate change. People in Central-Eastern Europe, in particular, have never met such extreme climatic conditions in the past. Therefore, cities weren't built to withstand this weather. Although there are numerous solutions for internal spaces, such as cooling systems and thermal insulation, there are still no effective solutions for open spaces, which is why open public spaces are deserted on a hot summer day. So, the question is: how can we turn these public squares back into our liveable and familiar spaces?

People have lived in such extreme climates in other parts of the world for a long time. They employed various solutions in their buildings, bazaars, public gardens and outdoor spaces. In the Middle East, there are various strategies for high-efficiency cooling in open spaces in hot weather. In this research, I examine historical architectural features found in warm cities of Iran. I collect specific and conventional solutions that rely on traditional building culture and can be applied at other locations.

The research aims to find new solutions for the countries of Central-Eastern Europe by inspiration from the traditional Middle Eastern solutions. My expected results are to define a new set of tools for the mentioned climatic challenge for using them in the design of new open areas.

## 2. Introduction

We have had a lot of issues recently due to climate change all over the world. Urban areas experienced one of those effects, which had an immediate impact on people's way of life. based on HSC (Health and Safety Executive) human body thermal comfort is between 13°C and 30 °C. While recently, temperatures in some central European cities reached 40°C. Due to the weather, fewer people are leaving their homes during the day. effect of climate change in east European cities As a result, there are fewer people using public transportation and more people driving their own cars and we face empty squares, plazas, and public places during the day on hot days.

### 3. Climate in Iran

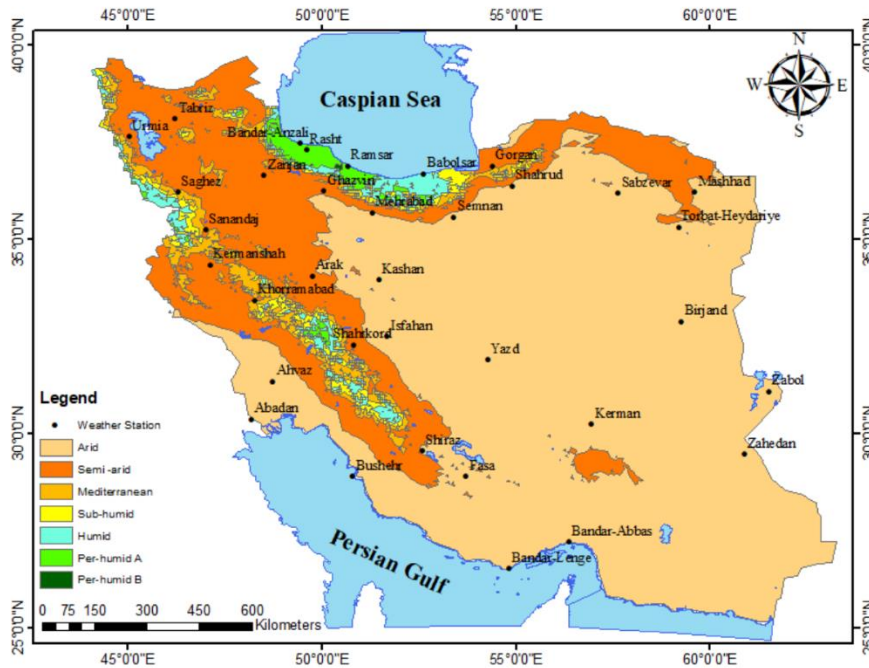


Figure1: Climates of Iran source: Abbasi, F., Bazgeer, S., Kalehbasti, P.R. *et al.* New climatic zones in Iran: a comparative study of different empirical methods and clustering technique. *Theor Appl Climatol* **147**, 47–61 (2022)

Iran is located at the top of the equator, which has three main different climates. These three main climates included: Hot-arid climate, a Mountainous cold climate, and a Humid and moderate climate. Most parts of Iran has a hot and arid climate. One of the features of this climate is cold winters and warm and dry summers.

In traditional Iranian architecture we can see it directly concerned with the climate in order to adapt it to the human body. By using different architectural elements and natural resources, and sustainable design, they reached an ideal temperature for people in each climate.

#### Urban design

there is evident urban design different between hot-arid climate and humid and moderate climate in Iran which is density. In hot-arid climate the cities are too dense, and streets are narrow out to have less consumption energy in winter and have more shadows in summer.

Another feature in hot-arid climate is introversion (Darungara) design. In this system buildings have central yard and all the openings are open to the yard. This central yard make shadow in all around the yard and because the heat capacity of air is low the temperature of curt yard adapt with surrounding very soon. However, this introverted also inspired from culture and history in Iran.



figure2: Yazd (hot-arid climate)  
source: website: www.dana.ir



Figure3: Mazandaran (humid and moderate climate)  
source: website: www.memarcad.ir

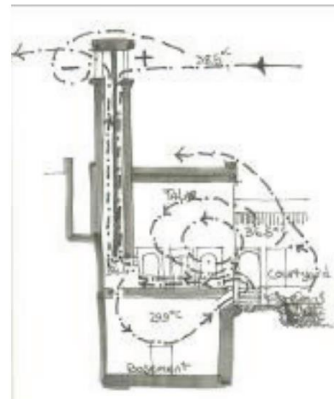
## 4. Architectural solutions in Iran

### 4.1. windcatcher(badgir)

badger is a historical element for cooling systems in traditional houses in arid regions in different countries in the middle east such as Iran, Afghanistan, Pakistan, Iraq, United Arab Emirates. it also has been seen infrequently in some other countries such as Syria, Lebanon, Palestinian Israel, Turkey Even though that it had a different name and different structure in different countries however all of them had the same function which is circulating prevailing wind from the rooftops to the living areas and make ventilation and cooling air in different ways. There are three different main types of badgir in Iran: Ardakani, Kermani, and Yazdi



(a)



(b)

Figure4: (a) 3D modelling of air trap; (b) Wind circulation, source: Parinaz Keshtkaran, Harmonization Between Climate and Architecture in Vernacular Heritage: A Case Study in Yazd, Iran, *Procedia Engineering*, 21, 2011, 428-438

#### 4.1.1. Ardakani badgir

this type of windcatcher is the simplest type of badgir in Iran. This badgir is used in Ardakan city, northwest of Yazd. It only has one intake which is toward to west with fresh wind and three other sides are faced with desert and sandy wind. Because this windcatcher is simplest in construction and economics it is usually built once in each room of a house.

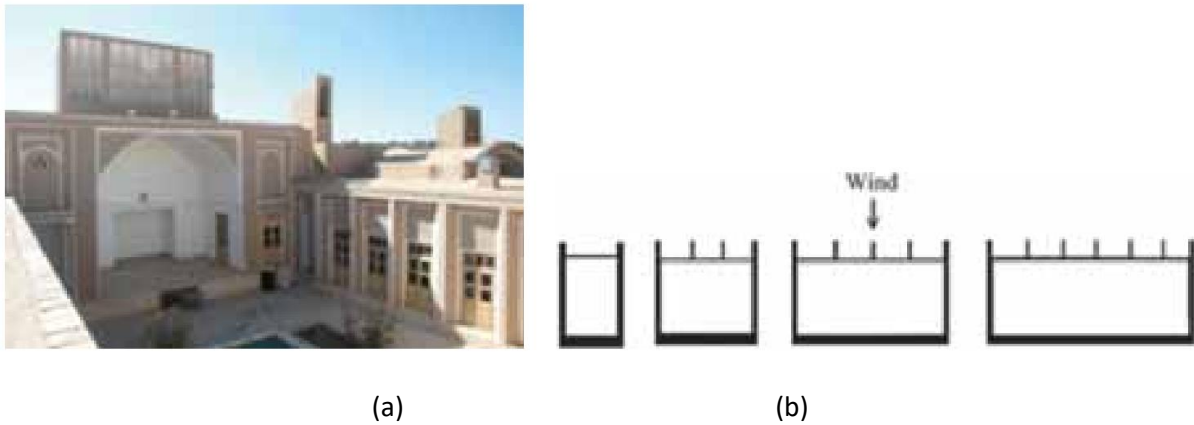


Figure 5: One-sided (Ardakani) badgir: (a) a house in Ardakan and (b) typical plans.

source: B. Hejazi & M. Hejazi, *Int. J. of Design & Nature and Ecodynamics*. Vol. 9, No. 1 (2014) 56–70

#### 4.1.2. Kermani badgir

this type is used in the city of Kerman. It is more efficient than Ardakani badgir. It has two intakes that take toward the most appropriate wind. Kermani badgir is mainly used for the building of water storage (water storage is buildings in each neighborhood or village in deserts for storing water for seasons with less rainfall)

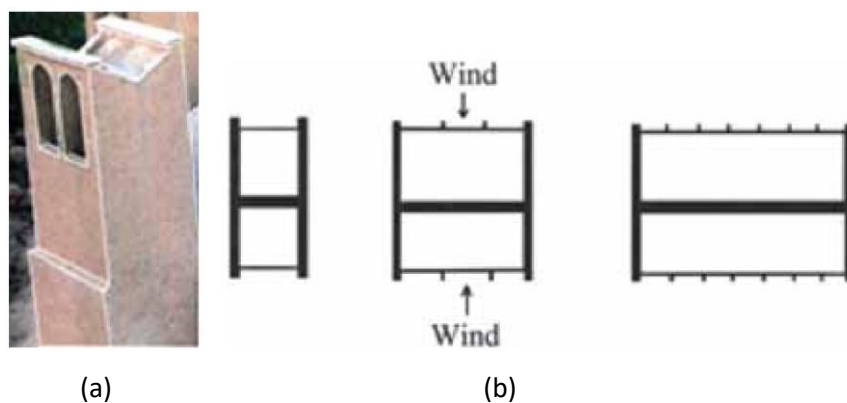


Figure 6: Two-sided (Kermani) badgir: (a) cistern of Dawlat-Abad garden, Yazd and (b) typical plans.

source: B. Hejazi & M. Hejazi, *Int. J. of Design & Nature and Ecodynamics*. Vol. 9, No. 1 (2014) 56–70

#### 4.1.3. Yazdi Badgir

this type is used in Yazd city. This city is located between two mountains, so it prevents entering sandy wind from the desert into the city. This type has four intakes which makes it

harder in terms of structure. Yazdi is the most efficient and complicated type of badgir in Iran. This type is taller and larger than other towers.

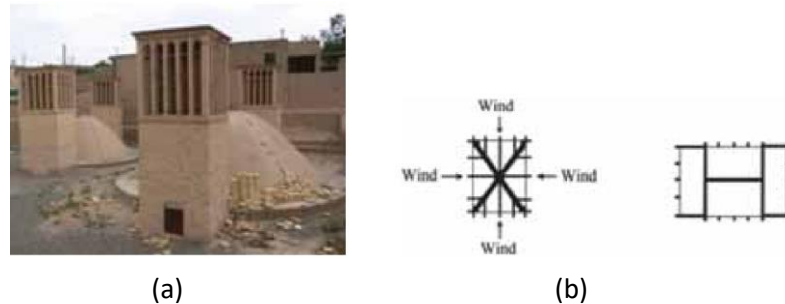


Figure 7: Four-sided (Yazdi) badgir: (a) a cistern in Nayin and (b) typical plans.

source: B. Hejazi & M. Hejazi, *Int. J. of Design & Nature and Ecodynamics*. Vol. 9, No. 1 (2014) 56–70

#### 4.2.Dome roof

Buildings in this area had dome-shaped roofs because of thermophysical reasons. Because of the curve shape of the dome half of that, there is always shade and half is face the sunlight. On top of some of the dome, there is an opening that moved the hot weather in top out and also makes air flow inside the house.

If the building has a flat roof it is built paved with square shape bricks called paved bricks. These bricks receive the most radiation of the sun. Early morning it starts to increase and late afternoon it decreases gradually.



Figure 8: roof of traditional houses with brick material, source: [www.dana.ir](http://www.dana.ir)



Figure9: roof of traditional houses with mud material, village of Mazar in arid climate source: author

### 4.3. Courtyard

In introverted houses, the yard is the main important element. it is the most social part of the house and all the members of the family gather in this area, children play there and even they host their guests, and at night some people sleep there.

In the Persian language, it is called a central yard. In the zoning of the house, all the areas are organized around the central yard.

the other main function of the yard in these houses is, making connections between several areas, gardening and refreshment area, artificial ventilation of the house, and quiet and peaceful area for people of the house.

the reason that courtyards are comfortable places in hot arid areas in terms of climate. There are several reasons that the courtyard has a comfortable climate. One of them is there are always shadows on two sides of the yard. in the design of the courtyard, the wider length is the opposite side of the sunlight direction so during the day in most of the yard there is shadow.

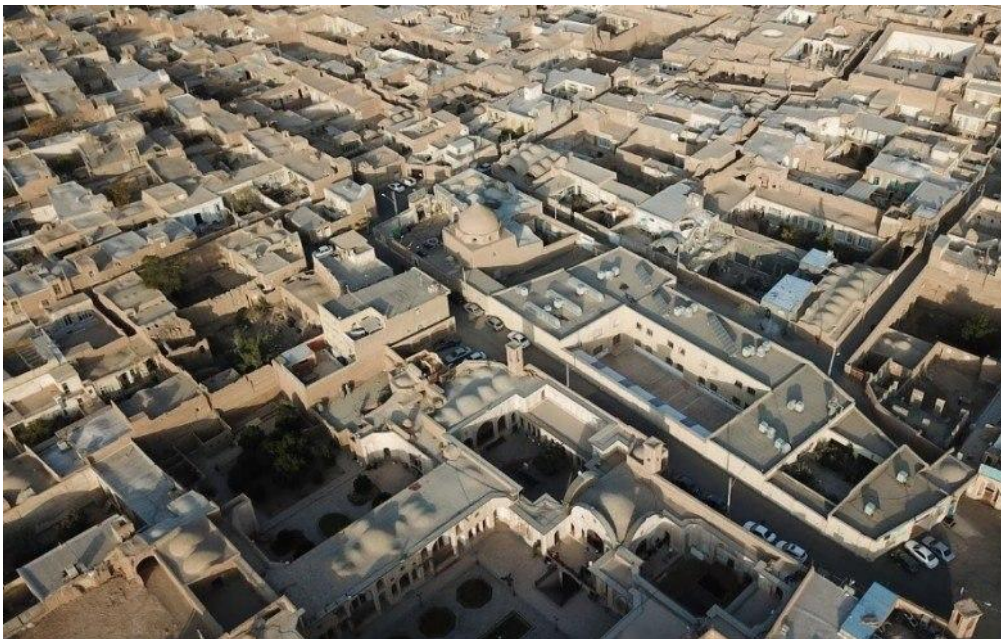


Figure10: top view of residential with courtyards houses in Kashan source: [www.kashanonline.com](http://www.kashanonline.com)



the second element is a pool. Pools with help of wind flow and vegetation make the climate of the yard cooler and more humid. The depth of these pools is usually from 40 to 100 centimetres. Some of the pools have small foundations which help have a better connection with the wind flow. The water sources of these pools were from water storage of houses or underground waters.



Figure11: pond in traditional a house, source: [www.archline.ir](http://www.archline.ir)

there is a different type of yard that helps more to have a cooler yard which is a deep courtyard (Godal baghche). these yards are one level underground the because of more shadows and connection with a lower level of soil which is wet and cooler these types of yards are more practical. These types of yards in some houses are surrounded by rooms in the basement and some others sounded by walls with some small storage and place and decoration.



Figure12: Godal baghche in Iranian historical house, source: [www.sedayememar.ir](http://www.sedayememar.ir)

#### 4.4. Gardens

In Farsnameh, Ibn Balkhi claims that Manoochehr, the son of Mishkhoriar, the seventh king of the Pishdadi dynasty (Iranian dynasties pre – Islam are: Pishdadian, Kianian, Ashkanian, and Sassanid) was the first one who built the garden. It has also been quoted that according to Gazanfoon the first one who made attempts to establish gardens was Cyrus, the great, he even used to plant trees.( Khademi & Kabiri & Hayat Khan, 2013) They were shaped like squares and rectangles.

The Iranian garden has three main features which span its history from Pishdadian to Pahlavi. The first is that they are all located along waterways, such as rivers, channels, or ganats. The sources of the water were one of the key issues in these gardens because they are sited in an arid area. Therefore, each of these gardens has a pond, pool, or other form of water storage. The second feature is that gardens have a building or palace at the centre of these gardens[figure13]. The final one feature is a symmetrical design.

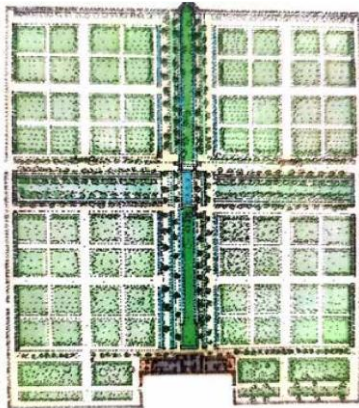


Figure13: design of Golshan garden as Chaharbagh and Kushk at the center  
source: Moravej Torbati & Hosseini, 2013, 96

There are several elements in gardens which effect on the temperature, the first one is vegetation. In Iranian gardens there are always two type of trees. One of them is season trees and yields trees other type is trees that are green all seasons for instant pine tree. The other one is water ponds and pools.



Figure14: vegetation of jahangosha garden with pine tree Deciduous trees ,  
source: Rezaei M 2021,p10

Iranian gardens are surrounded by a wall, one reason is the security of private gardens, however, some other climate gardens do not have a wall so the most important reason is to protect the garden from the hot and dusty wind of the desert.



Figure15: Shahzadeh garden in Mahan in Kerman  
sources: Seddigh, Karimiazari & Ghanaati, 2014

From Safavid (1501 \_1736) new type of gardens designed in city. Safavid was the first kingdom in Iran which converted the religion from Sunni Islam to Shia Islam. The capital of Safavid was Isfahan and they wanted to make their cities like paradise from the Islam perspective. So came out with idea of garden city. The urban plan of Isfahan been redesigned and the idea of Charbagh(traditional form of Iranian gardens) accomplished in larger scale in city of Isfahan

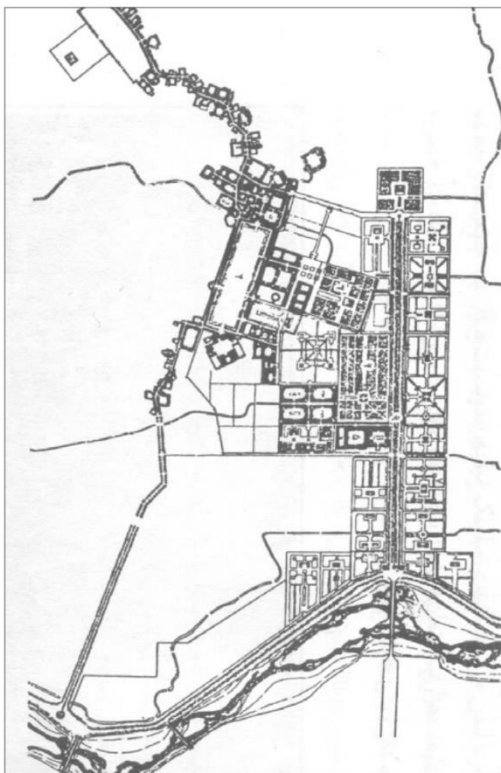


Figure16: Charbagh of Isfahan and connection with river during Shah Abbas (fifth king of Safavid)  
sources: Pirnia, 2001, 276

#### 4.5. Sabat

To protect people from the heat, streets and sidewalks are constructed mainly in the east-to-west direction. On hot summer days, the narrow sidewalks with high walls on both sides are completely in the shadows. (Tavassoli,2002) To prevent the hot air from flowing down the streets and sidewalks and entering the buildings, the sidewalks are mostly curved and narrow with high walls. Roofed sidewalks (Sabat) help keep the sidewalks in the shadows, and narrow sidewalks contribute to the density of nearby buildings. These narrow passages with high walls provide an effective solution for dealing with the harsh climate. (Moradi , 2005)



Figure17:Sabat source: [www.archline.ir](http://www.archline.ir)



Figure18:Sabat with neighbouring room, village of Mazar in arid climate source: author

#### 4.6. Materials

What attracts tourists and viewers of Yazd at first is the role of mud and molded materials (especially adobe) everywhere in the houses, on the sidewalks, and on the wind towers. Everything in Yazd has been designed to use construction materials that are formed from mud. Because of the climatic conditions, the use of mud materials in the desert, and especially in Yazd, is feasible and practical. Nothing is as resistant against the burning sun in these regions as adobe and mud, because rooms can be warmed with little internal heat during the cold-dry seasons. The main reasons for using these materials are that they are available and practical for applications in desert conditions. Adobe and mud have high thermal capacity, which is important because it takes a long time for the heat outdoors to pass through the walls and get into the indoor spaces of the houses. Adobe can delay the heat transfer from outside to inside for about eight hours, which means the heat that is accumulated in the walls during the day will warm the house at night when the outside temperature decreases. In critical conditions, buildings are built underground or in the heart of the hills so they will be less affected by the adverse weather conditions. (Meamarian,1999) [4] (Moradi , 2005)

#### 4.7. Summer area and winter area

Nature is an inseparable part of people's lives. It forces families to move to different parts of the house in different seasons. So, houses are divided into two parts, a summer area and a winter area. This feature can be seen in the houses in most cities of this region. In most houses in Yazd, the main part of the houses faces northeast. In the summer, the main part of the house is the summer area, which is in the shadows most of the time. Across the yard from the summer area is the winter area, which provides access to the warmth of the sunlight during the winter. The owner builds the two other parts depending on her or his financial status. Houses with yards in the middle and two other areas that connect the summer area and the winter area are called four-season houses. But the summer area best demonstrates the importance of the art of architecture in protecting people from adverse climatic conditions. (Tavassoli,2002)



Figure 19. Schematic section of a “house for four seasons” with a one sided wind tower above the summer living quarter (Source: Ali Tavakoli Dinani)

## 5.new solutions: case study Masdar city

Masdar City designed by Foster + Partners which is about 17 km from the centre of Abu Dhabi, is hosting businesses, researchers, and academics from all over the world, establishing an international hub for businesses and organisations specialising in clean technology and renewable energy.

Masdar City is an ideal city in the world because it is clean, eco-friendly, peaceful, and beautiful. It is an example of bio-conscious living in a carbon-free environment. conclusion. The desert, one of the world's harshest natural environments, is where this green city is located. When the desert winds temperature is 60 degrees Celsius in the middle of the day in the summer, it feels like 24 degrees inside the city. Foster + Partners drew inspiration from the design and architecture of traditional Arab cities and skill fully merged traditional construction methods with cutting-edge engineering. They combined these two different design styles to create a city where tradition is just as important as modernity.

This city will set a benchmark that will ultimately support sustainable development throughout Abu Dhabi and the region, as well as provide a functioning blueprint for sustainable living around the world.



Figure20: development plan of Masdar city source: [www.astroman.com](http://www.astroman.com)

### 5.1. wind towers

Masdar City wind towers take the cool winds from the surroundings and bring them into the buildings. In buildings, a thick protective layer against heat is considered. This ventilation have the highest efficiency because it keeps hot and dusty air during the daytime, and cooling the thermal mass at night by air movement.

this ventilation inspired from traditional windcatcher or Badgir or Malqaf (in Arabic) to make airflow in pedstrain.



Figure21:Contemporary reinterpretation of badgir

### 5.2. shading system

Different type of shading system in different public areas of this city helps to decrease the temperature of the open areas significantly.





Figure22: different type of shadings in Masdar city source: www.astroman.com

### 5.3. Facade

Window areas vary in response to daylight availability, and are positioned to wash walls and ceilings with daylight. Windows are protected by a contemporary reinterpretation of mashrabiya, a type of latticed projecting oriel window, constructed with sustainably developed, glass-reinforced concrete, coloured with sand to integrate with its desert context and minimize maintenance. Metering for each unit provides feedback to the building facilities manager and individual occupants on energy and water and cooling demand. The laboratories and residential accommodation are supported by a gymnasium, canteen, café, knowledge centre, majlis – or meeting place – and landscaped areas. Fresh air volumes reduced by over 40% through the use of active air management systems. Fully shaded windows minimize direct solar heat gain to reduce overall energy required for cooling (Ouroussoff N, 2010).

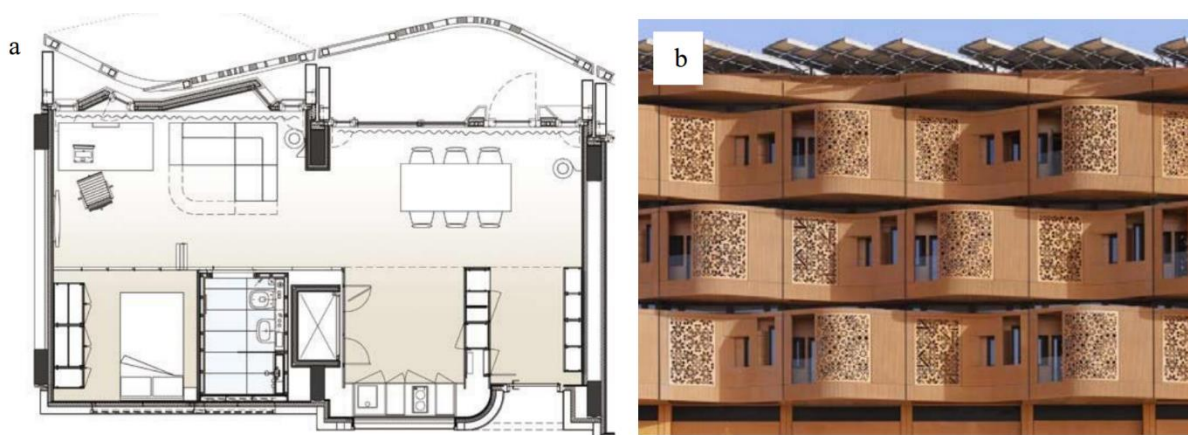


Figure 23. (a) Masdar city Residential buildings plan sample; (b) Residential building façade treatment source: Iman Ibrahim, Livable Eco-Architecture Masdar City, *Arabian Sustainable City, Procedia - Social and Behavioral Sciences*, 216, 2016, P 46-55



## **6. Conclusion**

In conclusion, by researching the conventional solutions for a region that has recently experienced warm weather as a result of climate change, we can find a sustainable solution. Foster and Partners created the same solution in Masdar City by drawing inspiration from traditional local architectural designs. For central European cities to create comfortable areas in the city during the summer, there could be a lot of ideas inspiring from traditional solution - in hot-arid climate.

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