The Climatic Performance of Iwan and its Impact on Comfortability in Traditional Houses

By

Hemin Muhamed Amin

Abstract

In Islamic architecture, traditional houses have been adopted to the contextual environment by minimizing harsh climate conditions and optimizing potential options for achieving indoor comfortability. Climate-friendly design is paid minor or no attention in the present time while traditional house design is packed up with instrumental resolutions for problems pertaining to climate which results in better thermal comfort indoor spaces. The current review article aims to deal with these problems and examine the performance of Iwan as an Islamic architecture element in different climates, as well as the advantages and disadvantages of Iwan to find out the probability of using this traditional space in up-to-date designs. The methodology that is used to deal with these issues is through the description, summarization, and the analysis of three research papers that are directly related to the study title in order to define the major results regarding the answer of the research questions which are 'Is Iwan's utilization advantages outnumber its disadvantages relative to climate performance or vice versa? and 'To seek out whether or not it is still usable in the present-time design'? The hypothesis states that the ups of Islamic traditional elements outweigh its downs. It also confirms that it is still usable in the current design. The study's findings will determine the efficiency of this space in various climates, and its positive and negative characteristics, as well as the impact of modifying the parametric factors and orientation.

Keywords: Islamic architecture, traditional houses, Iwan, Evan, indoor comfortability

1.Introduction

Traditional houses have been adopted in Islamic architecture to honor the environment by minimizing harsh climate conditions and optimizing potential options for achieving indoor comfortability. (Masoumian, 2014) Comparisons between traditional and contemporary dwelling designs indicate that the traditional dwellings, using the construction techniques, are more climate-friendly, resulting in improved thermal comfort in inside. (Shaeri et al., 2018) Traditional architecture has offered appropriate solutions for climatical condition in different regions. (Khalili & Amindeldar, 2014) One of the sustainable solutions that played a significant role in reducing climate problems in traditional houses was the use of iwan as an Islamic architecture element. (Nejadriahi, 2016)

Iwan is an external building element, utilized to increase the energy efficiency of a building via an architectural shade system. It has been recognized as one of the most essential parts of shading and passive cooling in the Middle East and North Africa regions. (Eskandari et al., 2018) According to several studies, passive and climatic elements such as iwan that used in traditional buildings can be applied in modern buildings (Izadpanahi et al., 2021). In this chapter, we will explain the iwan in terms of terminology and define it as an architectural element. As well as its function and climate performance will be discussed.

1.1The term of Iwan

For the first time, iwan used as an architectural element by Sassanian and improved in Mesopotamia. During the Seljuks' rule in the 10th century, iwan became a part of Middle Eastern and Islamic architecture. In term of terminology, iwan is a Persian word that has been adopted by Arabic, Turkish, and Kurdish languages, as well as western travelers. (Abdulrahman et al., 2019) In the Persian language iwan means “portico, open gallery, porch or palace” (Nejadriahi, 2016), but generally, as Dehkhoda dictionary explains, iwan or evan means doorway, forehead, doorway, and a high place with a roof used for sitting. (Kakizadeh, 2014). iwan has many names including (Ayvan, Ayvan, talar, and Ivan) and the same time's use (Loggia).(Foruzanmehr, 2015)

1.2 Definition

Iwan is often associated with Middle Eastern architecture. It's a rectangular hall or room that's normally roofed and walled on three sides. The fourth side is either partially or fully exposed to the yard via a portico (Abdulrahman et al., 2019). The reference (Kalantari et al., 2015) describes as a projection with two side walls or as a semi-open space with columns that are next to the building rooms in various forms, the same reference defines Iwan generally as “the half-open space which is enclosed at three sides and open at one side” (Kalantari et al., 2015)

Iwan also considered “as a space ahead and emphasizes on the entrance, and it is built as a connecting space in order to exist or inter a space”. (Kalantari et al., 2015) The same reference describes the Iwan “as a space that provides a range of life experiences in comparison to closed and open spaces by offering shade and a clear view of trees and greenery”.

1.3 Function

The overall iwan is located on the ground floor and overlooks the courtyard, it is easily accessible through the yard. (Foruzanmehr, 2010) iwan as a half-opened space is utilized in traditional buildings for various different purposes. It serves as a connection between a building's garden or yard and its rooms, as well as it used as an area for resting. Iwan also has climatic functions, such as providing shade from the hot summer sun, allowing indoor spaces that have been tuned to the iwan to stay cool. It's also used to build a pleasant microclimate by shielding against the fog, snow, and wind of winter. (Abdulrahman et al., 2019)

The reference (Foruzanmehr, 2015) discusses the significance of this semi-opened element in traditional houses; “It is not only a sophisticated expansion of the courtyard, but it is also an integral part of the house, being part of the construction”. While (Foruzanmehr, 2015) is defining more function of iwan, that during the summer season, it is alternately or concurrently used for sleeping, working, socializing, and even storage, in addition, the Evan serves as a transitional space between the indoors (courtyard) and the outdoors (house rooms), providing seating, sleeping, and circulation. An iwan, according to (Foruzanmehr, 2015) ,‘allows for casual observation and social interaction, and people will eat, play, and sleep outdoors for months of the year.'

2.The problem statement and the aim

In Islamic architecture principles and elements of traditional houses were utilized in such ways that were suitable in conjunction with contextual climate. This as the result led to the minimization of severe climate conditions and boosting possible options so as to fulfill indoor comfortability. One of the major elements of traditional houses that was used in the past, and it is still used is Iwan. Nowadays, people generally give minor attention to this significant element and its utilization has diminished.

The present review article aims at grappling with these problems and seeks the performance of Iwan as an Islamic architecture element in different climates and its influences on traditional house comfortability. It also examines the advantages and the disadvantages of Iwan to find out whether or not it still is usable in the present.

3.The research questions and hypothesis

The research questions for the current study include: 'Is Iwan's utilization advantages outnumber its disadvantages relative to climate performance or vice versa? and 'To seek out whether or not it is still usable in the present-time design'?

The hypothesis states that this Islamic traditional element's advantages outnumber its disadvantages relative to climate performance. It also affirms that it is still usable in the present-time design.

4. Data collection and methodology

The study consists of reviewing the related literature on papers and books that are directly in relation to our paper title. The procedure of the review study includes the following major steps: (1) defining the research scope and selecting the most important key words used to search in books and papers; (2) collecting papers and books which are direct to the research title or includes a number of important elements of the research title; and (3) analyzing the content and pinpointing the improvements of the research that have been shown in the articles.

Upon exploring the related books and papers on the internet so as to collect related materials on the titles, we read them and pick the ones which were very related to the title. Four related papers were left to undergo reviewing and several scientific publishes and books were employed to gather general information. figure (1) illustrates the research procedure, including; defining the research scope and selecting the title, and collecting and analyzing the data, as well as discussing and analyzing the research findings.

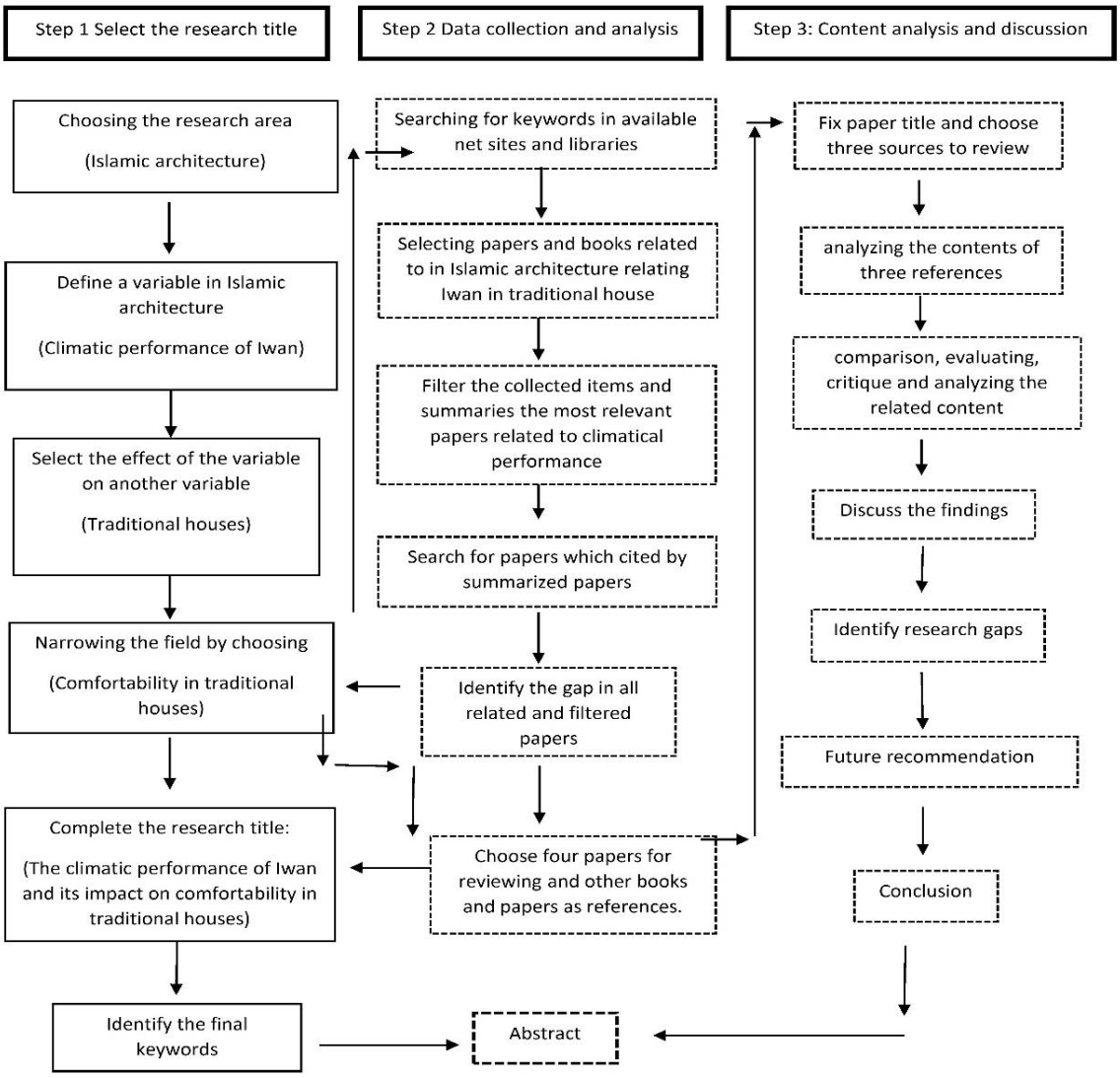


Figure (1): The data collection and methodology procedure. **Prepared by the researcher**

5. Literature review and case studies

After identifying the research scope and conducting a web search using the keywords (climatic performance as a variable and its effect on Islamic architecture), we discovered a plethora of research papers on the topic. We found four papers that included the previously mentioned variable to comfortability in traditional house indoors, as well as other books and research papers selected to be used as references, after noticing the research titles, abstracts, and conclusions and filtering out the founded papers (As shown in figure 1).

The selected research papers for this article review were conducted in various regions of Iran and Iraq countries. The research case studies put various house types to the test in terms of climatic variation, which includes four discrete climates: cold, hot and dry, hot and humid, and mild and humid. The case studies were examined using various methods and measurement instruments, as well as various techniques as a tool in the procedures. The studies emphasized the climatic benefits and drawbacks of Iwan's climatic impact on traditional dwellings. Table (1) analyzed the

four papers that will be examined for the relevant content, research methodology, the case studies performed and the most important conclusions related to our research. (As shown in table1)

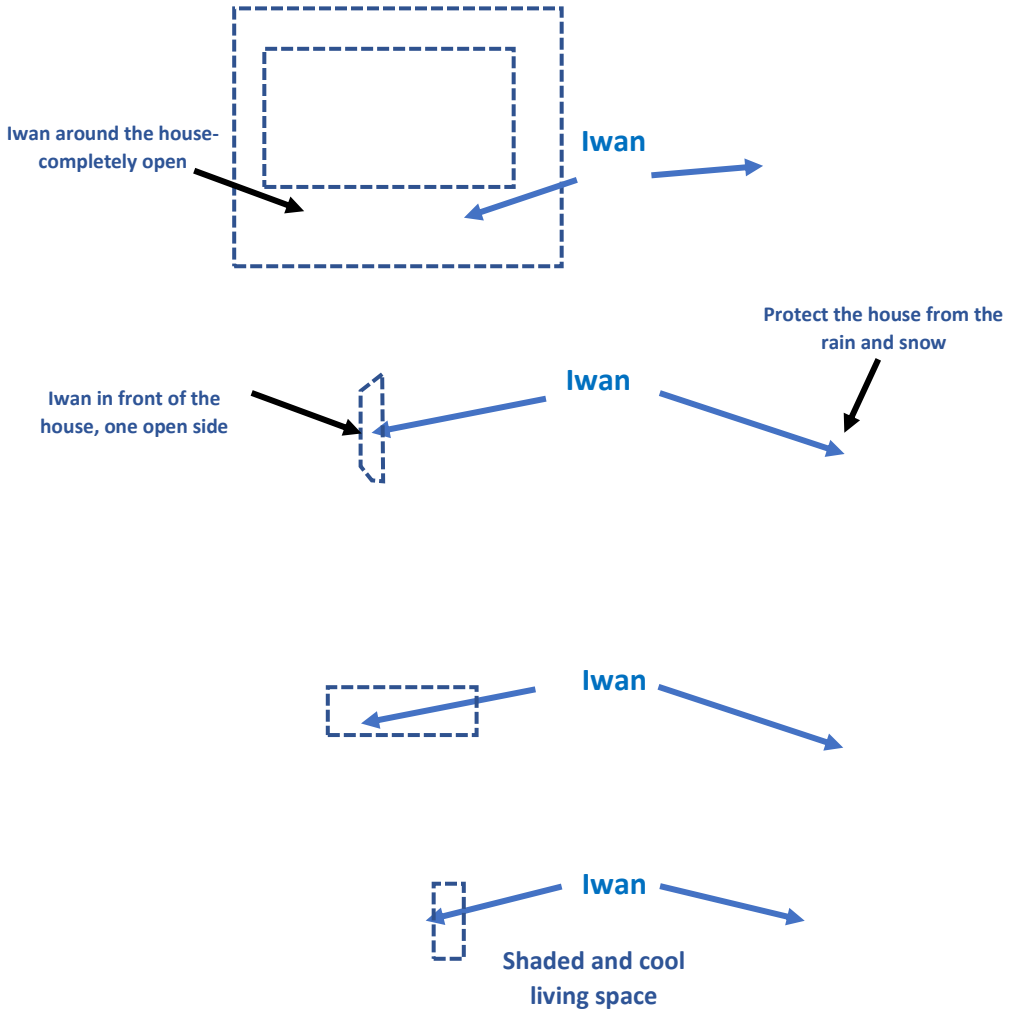
Table (1) summarizes the references used for reviewing the main content, methodology, case study, and related conclusion. **Prepared by the researcher**

Reviewed researches		The study's main content	Methodology	case study	The research conclusion related to our research
Review paper No.1	(Foruzanmehr, 2015)	The aim of this study is to evaluate the advantages and disadvantages of conventional loggias (Iwan), a vernacular passive cooling device in Iranian architecture.	The research methodology was done by giving 360 self-completion questionnaires to three study groups in Yazd, Iran. The surveys were made up of people from two separate groups: those who live in a typical community and those who live in a non-traditional neighborhood.	The case study was taken in two different districts with a questionnaire about the Yazd's citizen's perception of the Iwan. The surveys were made up of people from two separate groups: those who live in the traditional and non-traditional communities.	According to the study, Iwan is responsible for a variety of positive and negative causes, and thermal comfort considerations were one of the positive points. However, the disadvantages of this space, have outweighed the benefits, and they are no longer seen in modern housing projects.
Review paper No.2	(Nejadriahi, 2016)	This study examines the effects of Iwan on energy consumption as an external shading space in various climate regions and guidelines numerically and experimentally.	By using the Energy Plus program, the study has calculated the thermal loads of a building without iwan, and four different types of iwan from different temperature regions in Iran are applied, as well as the impact of iwan on thermal load reduction for four different climates.	The characteristics of iwan have been investigated for four distinct climatic regions in Iran: (1) mountainous-cold climate; (2) dry-hot climate; (3) humid- temperate and climate; and (4) humid -hot climate.	The best Iwan direction is south, according to the results of the research; in addition, in temperate and humid climates, the use of iwan could reduce energy consumption by 32 percent, whereas other climatic conditions, like warm-hot and hot dry climate, could reduce energy consumption to a lesser extent.
Review paper No.3	(Abdulrahman et al., 2019)	The study seeks to find out the effects of iwan's dimensional variables on the solar incidents, as well as to define the best and worst orientations for iwan in Sulaymaniyah as a climatic sensitive architecture technique, as well as to investigate the effects of iwan orientation on sunlight exposure.	The technique for conducting the study is carried out by the same parameters obtained from the study of Sulaymaniyah's traditional iwan samples were used to construct a three-dimensional concept model for an iwan using the Euclid extension and Google SketchUp software programs.	The iwan of 22 traditional houses in Sulaymaniyah city center was examined in this study; the selected case studies have a history dating back to before the 1950s. Five of the traditional house samples are registered in Sulaimanyah Museum as cultural Heritage houses in 2017.	The annual solar output of the iwan is one of the key factors in choosing the orientation of the iwan in traditional houses in Sulaymaniyah's old town, according to the study's findings, since most of the cases are in the best range. Other climatic conditions, such as the prevailing wind, may, however, play a role.
Review paper No.4	(Eskandari et al., 2018)	The study's main content is about the background and evolution of iwan in Iranian classical architecture. In addition, it discussed the changing of iwans performance according to different climate regions and evaluating them with the sustainable indicators.	This study used a descriptive and analytic approach in research methodology to determine the climatical role of iwan in four different regions in Iran.	The study exams the traditional houses that have iwan in Iran, and deals with various types of iwan in four different climate territories, which are: mild-humid, cold, hot-humid, and hot-arid climates.	The study's conclusion uncovered the significance of iwan's climatic concepts that plays a major role, which effectively guides the temperature of adjacent indoor areas, lowering energy demand and, as a result, improving sustainability.

6.Discuss the research findings

6.1 The performance of Iwan in various climates

Traditional houses are often influenced by a variety of factors, including climate, which is one of the essential aspects that determines the design of houses in order to create spaces in which people feel more confident. Iwan is among the conventional elements that, if well designed and suitable for the territory's environmental conditions, may play a significant role in energy consumption. (Nejadriahi, 2016) According to study (Nejadriahi, 2016), The effect of four distinct climates on iwan's function, and its effect on traditional houses as a whole will be discussed in this section. (As shown in figure 2)



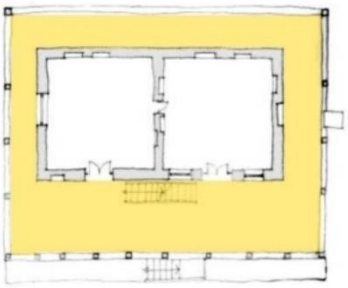
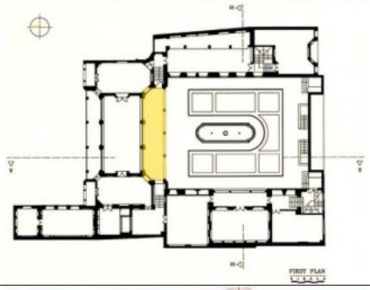
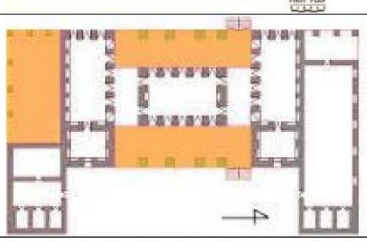
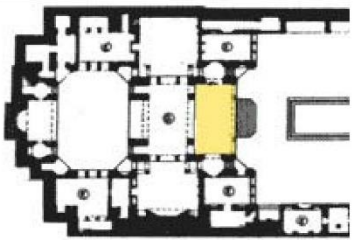
Climatic Regions	Traditional Houses		
	Plan	Figure	Climatic Role of Iwan
Mild and humid			-Iwan around the house as a buffer space to protect it from the rain -To create airflow and to reduce the moisture -To protect the house from direct sunlight during the summer while letting the light come in during the winter
Cold			- Iwan along the main axis of the house to have the maximum advantage of southern sunlight -To protect the house from the rain and snow -As a cover, which prevents the penetration of coldness into the building
Hot and Humid			- Wide and high Iwans around the central courtyard creates both shadow and air ventilation
Hot and Arid			-Open to the courtyard, which allows summer breeze and light to enter the spaces beyond - To create shaded and cool living spaces -To provide an indirect light

Figure (2) Climatic role of iwan in the traditional houses of different climatic regions of iran. Source: (Nejadriahi, 2016))

A. The performance of Iwan in mild and humid climates

The firs type of Iwan's climatic efficiency that reference (Nejadriahi, 2016) examines is (mild and humid) climate. This climate type has he following characteristics: low diurnal temperature variations, extreme precipitation, and a high humidity ratio throughout the year, and broad distribution of vegetation. In such an environment, semi-open spaces like Iwans built around the building to provide a buffer area from the rain caused by the wind. One of the primary methods for dealing with humidity is to use natural ventilation. As a result, Iwans were used to generate ventilation and decrease humidity.

Buildings in this area are extroverted in order to benefit from natural ventilation. Iwans were often used as a relaxing area for everyday activity or night sleeping during the summer because of the use of natural ventilation. Furthermore, Iwans in these buildings protect the house from intense sunshine during the day.

B. The performance of Iwan in cold climates

The second climate in which Iwan has been studied is cold weather. The extreme temperature variations between day and night, cold winters and mild summers, low humidity, and winter storms are characteristics of this climate category. An exploration into the climatic role of Iwan in the houses of this area reveals that Iwan is usually positioned along the main axis of the house to take advantage of the greatest amount of southern sunlight.

Iwan also keeps the house dry in the snow and rain. As a result, the presence of Iwan in the ground floor level of the building preserves both its architectural and climatic functions. In the winter, the Iwan works as a cover, preventing cold air from entering the building. Most days of the year in this climate region are cold or very cold, so most everyday tasks actually occur within the house. As a result, yards in this area are significantly smaller and its depth is much lower than other climate regions that do not have sitting rooms like those in the Caspian region, and they are mainly used to protect the house from rain and snow.

C. The performance of Iwan in hot and humid climates

The third climate category is hot and humid, which has distinct characteristics such as very high evaporation and air humidity throughout the year, very hot and humid weather in summer and mild weather in winter, low annual rainfall, and low diurnal temperature changes. As a result, in this area, creating shadows and using airflow are essential strategies for a more comfortable living environment.

Iwan is an essential place in the houses of these climate zones because it provides both shade and natural ventilation. The large and high Iwans surrounding the central courtyard are used as living space for the majority of the year, and numerous events have taken place there. Iwan also bridges the rooms, and in terms of view and relation to the yard, he plays a crucial role in these houses.

D. The performance of Iwan in hot and arid climates

The fourth and final climate zones are hot and arid, with little or no rain for at least six months of the year, resulting in a very hot and dry climate. This region's climatic characteristics include a very

low amount of rain, hot-dry weather, less vegetation, low humidity, hot summers, and cold winters, and high diurnal temperature variations. Iwans in this region's buildings are accessible to the courtyard, allowing summer breezes and light to reach the spaces beyond.

Iwans are usually found on the southern side of courtyards, with the open side facing north. This enables Iwan to get an indirect light of the northern sky without allowing overt light into the house, as well as control the depth and amount of sunlight into the building in summers and winters depending on resident needs for solar energy. South and east-oriented Iwans, in particular, are very cool and shady places in the afternoons in summer.

Concluding from this discussion:

The previous section examined at Iwan's performance and its influence, which differs depending on climate zone. We can conclude that the Iwan's position as a place, its climatic purpose, form or size, and its usage changes in different climate zones. These changing as the conclusion illustrates in table (2) below.

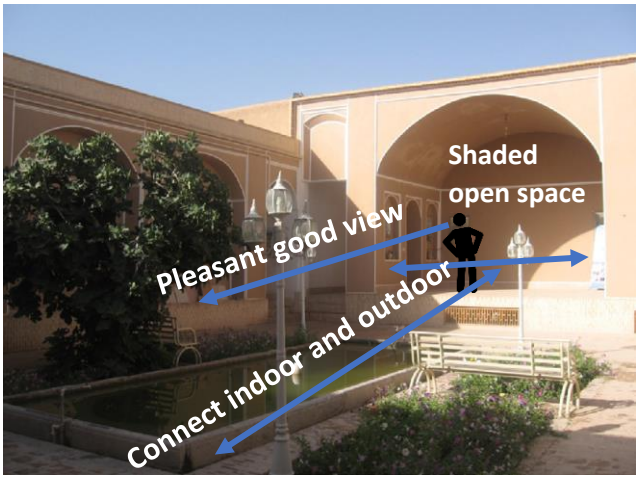
Table (2) illustrates how Iwan changes in different climates. **Prepared by the researcher**

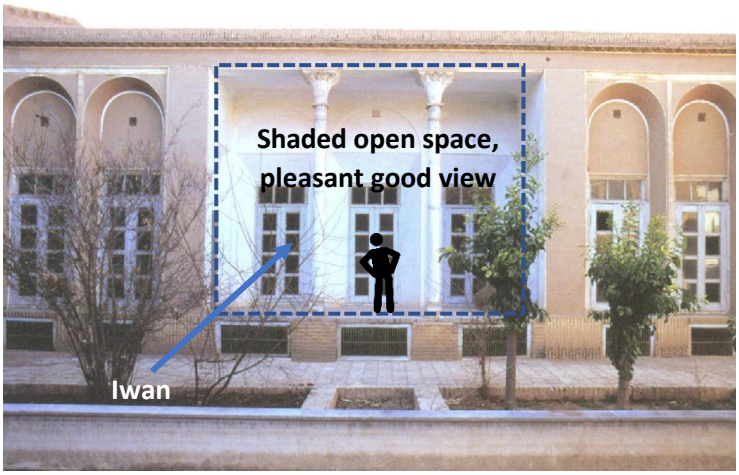
Climate	Position	Climatical function	Shape or size	Using
mild and humid	Iwan arranging around the house	-Working as a buffer space to protect the house from the rain in winter and direct sunlight during summer -To generate natural ventilation.	The houses Iwan in this area are extroverted	Iwans are using as a relaxing area for everyday activity or night sleeping during the summer
cold	Iwan positioned along the main axis of the house in the ground level	-To have maximum advantage of southern sunlight. -To protect the house from rain and snow. - Prevents the penetration of coldness	Iwans are smaller in size and lower in depth	-On cold days, Iwan is used as a space to connect the house rooms and yards without living; in the summer, it is used as a relaxing area.
hot and humid	The position is around the courtyard	To create shadow and providing ventilation	Iwans in this climate are wider and higher	Iwan is used as living space for the majority of the year
hot and arid	Iwan is placed on the southern sides of the courtyard with open sides facing north.	-To allow the summer breeze and light to enter. -To create shaded and cool living spaces -To provide an indirect light	Iwans in this climate type is normal regarding the shape and size.	South and east-oriented Iwans are very cool and shady places in the afternoons in summer uses as living area.

6.2 Climatic positive and negative points of Iwan's performance in dwellings

Despite the fact that several technologies are used in contemporary houses to achieve indoor thermal comfort, many researchers have found passive and climatic techniques used in traditional buildings can be applied in modern houses. The research (Foruzanmehr, 2015) deals with the importance of iwan and created a questionnaire in two separate districts in Yazd, Iran's hot-dry territory, to investigate its existence and significance in contemporary architecture. The existence of traditional elements, such as Iwan or Loggias, was explored in the research questionnaire, and the citizens' perceptions of enjoining this space in their homes, as well as the positive and negative aspects of Iwan. (As shown in figure 2)

According to (Foruzanmehr, 2015), 50 % claimed to have an Iwan or Loggia in their homes, which they use at different levels during the seasons. For the people's perception about enjoying this semi-space in their houses, 67% of respondents prefer the iwan presence in their dwellings, while only 22% of them did not like it in their dwellings and 11% did not answer the survey question. Based on the current responses, Iwan or Loggias are preferred by the majority of Yazd residents who live in traditional homes. (As shown in table 3,4)





	Whole sample		Traditional		Non-traditional			
			Sample 1 central courtyard houses		**Sample 2** new courtyard houses		Sample 3 flats	
	F	%	*F*	%	*F*	%	*F*	%
Yes	139	67	62	89	54	67	23	40
No	46	22	6	8	19	24	21	36
Blank	23	11	2	3	7	9	14	24
Total	208	100	70	100	80	100	58	100

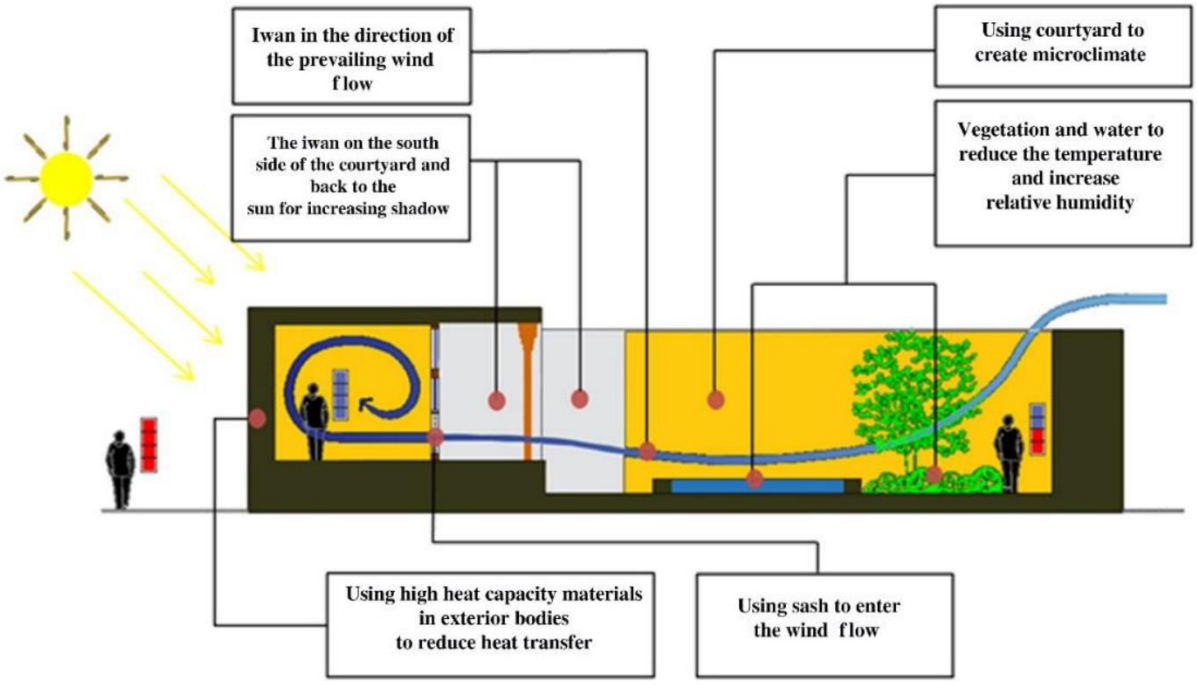


Figure (4) Section of a n Iwan type illustrates the comfortability in Iwan.

A. Climatic positive points of Iwan performance in dwellings

The Yaz's citizen's reply to a semi-open query about traditional houses with iwan revealed the key benefits of iwan in general. According to the survey, 37.2 percent of respondents rated "pleasantly spacious/commodious with a good view of the courtyard" as one of the iwan's most appealing features. In addition, "the flexibility of this semi-open space about relaxing and getting together" received 25.3 percent of the positive responses, while "having new and cool air" and "contributing to energy savings" received 21.7 percent and 6.9 percent of the positive responses, respectively. The next most frequently listed positive points in the result table were: (well-lit/shaded 4.1%), (open space 2.3%), and (open space 2.3), as well as a minority of the respondents offered other

Table (5) Positive comments about loggias (iwan). Source: (Foruzanmehr, 2015)

	Whole sample		Traditional		Non-traditional			
			Sample 1 central courtyard houses		Sample 2 new courtyard houses		Sample 3 flats	
	F	%	*F*	%	*F*	%	*F*	%
Pleasantly spacious/commodious (*delbaz*) with a good view onto the courtyard	71	32.7	28	29.8	27	36	16	33.3
Multifunctional space for resting and getting together	55	25.3	26	27.7	15	20	14	29.1
Having fresh and cool air	47	21.7	26	27.7	10	13.3	11	22.9
Contributing to energy saving	15	6.9	8	8.5	4	5.3	3	6.3
Well lit/shaded	9	4.1	0	0	6	8	3	6.3
Open space	5	2.3	0	0	4	5.3	1	2.1
Usable in different seasons	4	1.8	0	0	4	5.3	0	0
Easily connected to the courtyard rooms	7	3.2	4	4.3	3	4	0	0
Other	4	1.8	2	2.1	2	2.7	0	0
Total	217	100	94	100	75	100	48	100

reasons that shown in the table (5).

B. Climatic negative points of Iwan's performance in dwellings

Table (6) illustrates that "dustiness and difficulty of maintenance" was the first frequently questionnaire response among 112 negative answers with 27.7%. In addition, "Limited usability" and "Land intensive and low space-efficient" were the second and third most common responses to the negative points, with 26.8% and 22.3 percent, respectively. According to the research, Iwan or Loggia is not accessible and comfortable throughout the year; in the summer, it is only useful for a few hours per day, and temperature and light are difficult to regulate. Furthermore, since the temperature cannot be controlled during the cold days of winter, some home owners have added a barrier in iwan for the winter months to keep the cold air out. Other less commonly reported negative aspects of loggias were their "lack of control over climate conditions" (8 percent), "inapplicability to modern dwellings" (6.3 percent), "Having bugs, insects and vermin" (6 percent),

Table (6) Negative comments about loggias (iwan). Source: (Foruzanmehr, 2015)

	Whole sample		Traditional Sample 1 central courtyard houses		Non-traditional Sample 2 new courtyard houses		Sample 3 flats	
	F	%	*F*	%	*F*	%	*F*	%
Dusty and difficult to keep clean	31	27.7	14	43.8	10	21.7	7	20.6
Having limited usability	30	26.8	10	31.3	12	26.1	8	23.5
Land intensive and low space-efficient	25	22.3	6	18.8	10	21.7	9	26.5
Lacking control on climatic conditions and privacy	9	8	0	0	7	15.2	2	5.9
Inapplicable to modern dwellings	7	6.3	0	0	5	10.9	2	5.9
Having bugs, insects and vermin	6	5.4	2	6.3	1	2.2	3	8.8
dangerous for toddlers and children	3	2.7	0	0	1	2.2	2	5.9
Other	1	0.9	0	0	0	0	1	2.9
Total	112	100	32	100	46	100	34	100

and "being unsafe for toddlers and children," (3 percent). As shown in Table (6)

Concluding from this discussion:

Despite the fact that contemporary design incorporates many sophisticated technologies and new elements, many passive and climatic techniques of traditional architecture are still used. According to the study (Foruzanmehr, 2015), more than half of Yazd's dwellings still have iwan and use it as a semi-open space, and the majority of the city's residents are comfortable with this traditional element, indicating that it is useful and workable in recent architecture.

As a traditional semi-open space, Iwan has both positive and negative aspects. Based on the findings, we can conclude that the most positive aspects of Iwan are directly related to Iwan's climatic performance factors, whereas the most negative aspects of this space are not related to its climatic performance. As a result, we can conclude that the climatic benefits of iwan as a conventional space outweigh the drawbacks. It is also concluded that the majority of residents who have Iwan in their homes still enjoy having it and are generally satisfied with it.

Despite the fact that Iwan has many benefits related to its climatic role, in terms of climate factors it suffers from controlling the space temperature throughout the year, especially in regions with

different temperatures in summer and winter. We can conclude that Iwan is more appropriate for dry regions with a homogeneous temperature, but barriers in Iwan are recommended for regulating the comfortability of space in regions with all or a portion of their climates being cold.

6.3 The performance of the iwan based on the parametric variables and orientation

Reference (Abdulrahman et al., 2019) investigates the iwan of 22 traditional houses in Sulaymaniyah, Iraq, in terms of the role of parametric variables (orientation and dimension) of the iwan on the space itself, as well as its effect on the houses as a whole. The houses were approximately 3.0 meters high, with depth-to-width ratios ranging between 1:1 and 1:2. The depths of iwan were then assumed by 4.0, and a simulation of a standard 3D prototype was performed using Google SketchUp and the Euclid extension. To obtain results, models were simulated and analyzed in various orientations. (As shown in figure 5&6)

Figure (5) Six examples of traditional houses with iwan in Sulaymaniyah's old town. Source: (Abdulrahman et al., 2019)

The findings reveal that changing all parameters, which are the iwan's depth to width ratio and its orientation, induces changes in the (AIV) of the iwan's inside faces. We will discuss and summarize the research findings in these points:

A. The performance of the iwan based on the orientation

- The best azimuth angles for all iwan sizes are 135° to 225°. 82 percent of the orientations of the houses whose Iwans were analyzed are in the optimal orientations range.
- The worst azimuth angles for all iwan ratios are 315° to 45°. None of the Iwans' orientations in the investigated dwellings are in the worst orientations range.

B. The performance of the iwan based on depth to width ratio

- The best-case study is the iwan of house number seven, which has a depth to width ratio of 1:1.5 and is oriented south, with an Annual Insolation Value (AIV) of -239W/m2.
- The worst-case study is the iwan of home number three, which has a ratio of 1:1.6 and is oriented to an azimuth angle of 250°, with an AIV of -287W/m2.
- According to the AIV findings, Iwans with lower depth to width proportions had greater yearly solar performance than those with greater proportions. In the analyzed dwellings, 59 percent of their iwan have a D:W ratio that is equal to or less than 1:1.5, while the remainder have a larger ratio. This middle ratio (1:1.5) of iwan proportions is repeated twice throughout
- the case studies with azimuth angles of 180° and 190°.

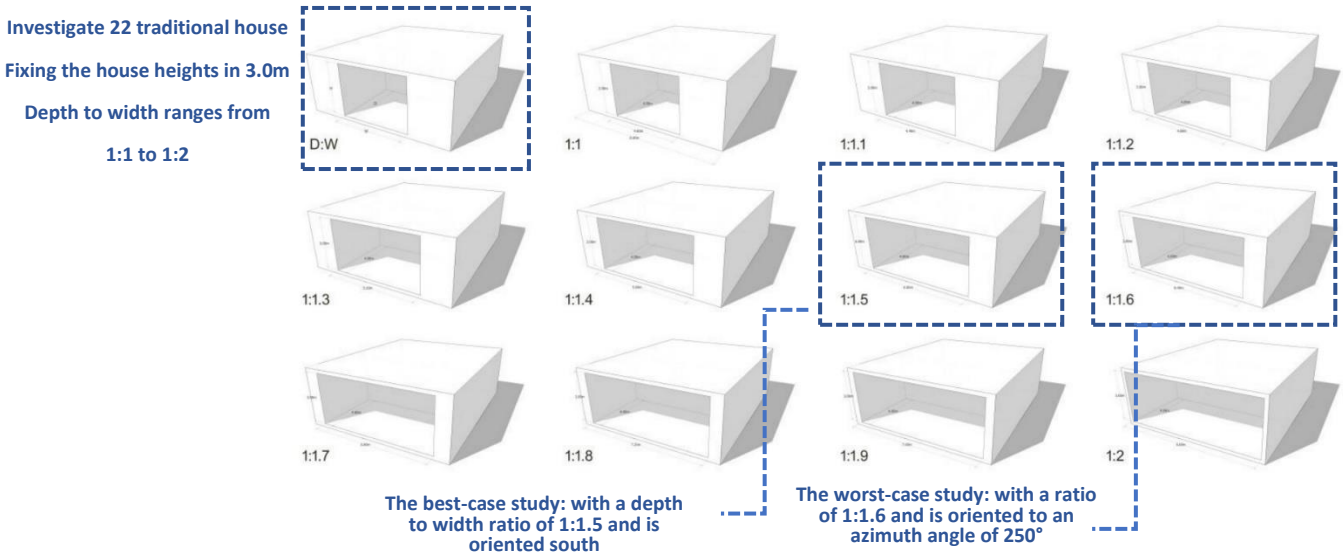


Figure (6) 3D models of considered iwan proportions in simulations. Source: (Abdulrahman et al., 2019)

Concluding from this discussion:

Sulaymaniyah, Iraq's northernmost city, has a variable climate, with two very different temperatures in the summer and winter seasons. The role of the Iwan as a house space is critical, and it varies by changing its orientation and parametric variables. Based on the findings, we can conclude that the best azimuth angles for all iwan proportions are 135° to 225°, while the worst azimuth angles for all iwan proportions are 315° to 45° in this city. Furthermore, the best dimension ratio is a depth to width ratio of 1:1.5 and is oriented south; the worst-case study is a depth to width ratio of 1:1.6 and is oriented to an azimuth angle of 250°. In Sulaymaniyah and other regions that their climates similar to it, Iwan has a climatic response and could be used in the design of Sulaymaniyah buildings. In this study, we found that changing the parametric variables and orientation of the Iwans affects its performance in traditional buildings.

6.4 The effect of Iwans form and depth on its performance in traditional houses

Iwans were utilized in nearly every climatic region, although they vary from area to region in depth, height, form, size and direction of location. Iwan forms are determined by the building plans. Iwans are typically surrounded on one, two, or three sides. The reference (Eskandari et al., 2018) examines iwan as a shading device and assesses its impact on building energy consumption by testing the five various forms in four different Iranian climates and tests Iwans width to determine the best iwan depth regarding energy consumption.

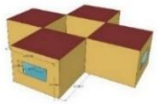
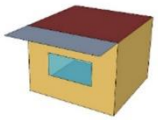
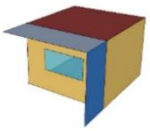
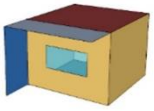
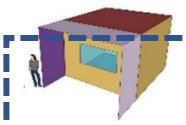
The reference used a four-meter squire room plan of an iwan with a three-meter fixed height and assumed all the room components and placed a window opening with a dimension of (2*1) m above 1m. The findings of the study are based on computer models and experimental data, whereas Energy Plus generates numerical data.

A. The performance of iwan’s different form in traditional houses

One solution for reducing a building's cooling load is to build an Iwan over the warm side of the building and use different Iwan forms and dimensions depending on the climate. An Iwan's height is typically equal to the height of a building's roof, and it has a depth of 1–2 m. In addition, Iwans are typically enclosed on one, two, or three sides.

So, in order to investigate the effect of Iwan on the cooling load, an Iwan was placed on each of the building's sides. First, an Iwan in the form of an overhang was added in each of the building's four directions. In the following step, a side fan as wide as Iwan depth was added to the right side of Iwan in each of the four directions. The fan was then moved from the right to the left side of the space. In the final step, two fans were added from Iwan's right and left sides in each of the four

Table (7) Steps of Iwan forms placement. Source: (Eskandari et al., 2018)

Steps	Explanations	Figures
0	Building placed in four orientations with rooms of 4 × 4 dimensions, three meters height and openings of 1 × 2 in four climates	
1	An overhang with 1.5 m depths added to the top of openings to all zones	
2	Overhang placed at the top section and a side fan with 1.5 m depth added to the right side of opening	
3	Overhang placed at the top section and a side fan with 1.5 m depth added to the left side of opening	
4	All above-mentioned steps used synthetically and then, with 1.5 m depth designing plan continues	

The best case is Iwan with three sides, south orientated and with 1.5m depth

ex

For each of the four directions, the numerical simulations investigated a different Iwan mode. The simulations were run for four distinct climatic zones, and the building's heating and cooling demands were estimated. Also explored were the impacts of orientations on the energy optimization obtained by all Iwan shapes. First, the building was modeled with no Iwan placed in any of the four orientations, and then simulations were run for four different types of Iwan. Six distinct Iwan depths were investigated. In total, 120 distinct instances were simulated. According to the study results that shows in (Table 8, Figure 6), It is being concluded that:

- After using an Iwan, the cooling loads decrease, while the heating loads increase.
- The Iwan acts in this situation as a building cooler which reduces the demand for cooling and increases the load on heating in all climatic conditions.
- The maximum cooling load reduction on the south elevation of the house happens in all clamatical conditions, and Iwan Form S4 is the best form among Iwan forms, as it minimizes a building's thermal load.
- Iwan Forms S2 and S3 had almost no effect on the outcomes, but Iwan Form S1 had the most effect.

Table (8) Thermal load analysis after Iwan insertion: (Eskandari et al., 2018)

Climate	Temperate & Humid				Hot & Humid				Cold & Mountainous				Hot & Dry			
Zones Direction	N	E	W	S	N	E	W	S	N	E	W	S	N	E	W	S
Max decrease rate of cooling load				*				*				*				*
Min decrease rate of cooling load	*				*				*				*			
Max increase rate of heating load				*				*				*				*
Min increase rate of heating load	*				*				*				*			
Difference between max cooling and heating (W)	470				1125				114				611			

B. The performance of iwan's depth in traditional houses

In order to decrease thermal load for the dwellings, we have to estimate the optimum Iwan depth at the south elevation of Iwan in any climatic environment. In a cooling charge analysis (Figure 6), an Iwan with a profile of 1.5 m reduces the cooling load noticeably and gradually; the differences in results, however, are inconsequential above a depth of 1.5 m. The use of Iwans at a depth of 1.5 m is therefore the optimal solution to lower the requirement for cooling.

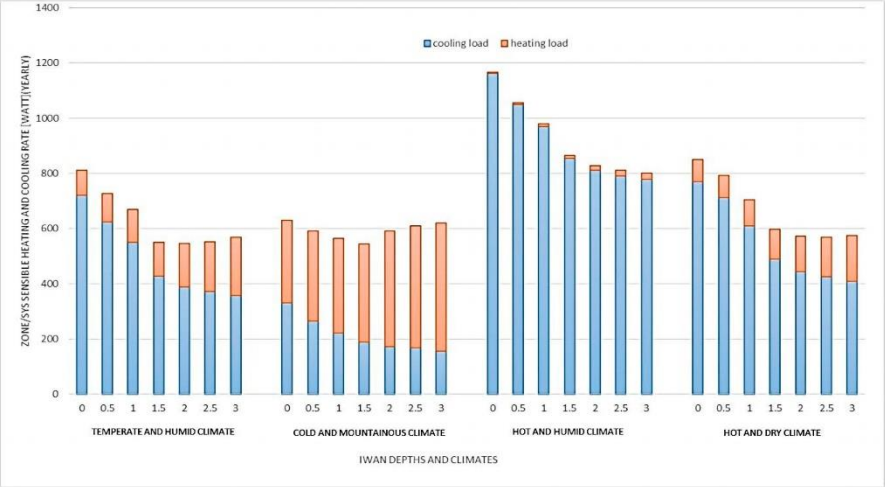


Figure (7) Thermal loads of southern zone based on the Iwan depth. Source: (Eskandari et al.,

In this regard, increasing the Iwan depth and hence the shade increases the heating burden in all climates. In terms of a building's thermal load, we can state that in temperate & humid and dry & hot conditions, Iwans of 1.5 m depth achieve the lowest thermal load, while in cold & mountainous locations, Iwans of 0–1.5 m depth lower the thermal load slightly while Iwans of bigger depths increase it. In hot and humid weather, Iwans with a depth of 3 m have the lowest thermal load, although there is no significant difference in thermal loads when Iwans with a depth of 1.5–3 m is used. When utilizing Iwans with a depth of less than 1.5 m, there is also a steady rise in thermal load. In general, the ideal depth for Iwans in all climates is 1.5 meters.

Concluding from this discussion:

Based on the study's findings, we may investigate Iwan's performance and summarize the impact of the variables indicated in the study that the roof of an Iwan is the most essential architectural component since it can result in a significant drop in temperature. The southern elevation is an ideal direction to use Iwan because it provides a maximum thermal heating and cooling load rate and an Iwan maximum thermal load reduction rate. The optimum height for Iwan use in any climate is the southern elevation of a home, according to diagrams and calculations. Furthermore, we may conclude that, in general, the ideal depth for Iwans in all climates is 1.5 meter and the best form is Iwan with three sides in all climate types.

7.Study gaps and future recommendations

The findings of the research were discussed in-depth, with several facets of Iwan as a traditional element being studied, and it was discovered that there are gaps in the study field. We would propose the following as future recommendations:

- Examine the use of this traditional element in contemporary architecture and development to make it more appropriate to today's lifestyle by using new technology.
- The investigation Iwan's various forms of traditional dwellings in Kurdistan’s different climates

8. Conclusion

Traditional principles and elements had influential impacts on climate-friendly house designs which resulted in minimizing harsh climates and optimizing potential alternatives for comfort indoors. A major element that was utilized in traditional houses and had climate effects on houses is Iwan. Gathering books and papers related to the title of the study, and filtering them out, only four of them were left to undergo reviewing. By analyzing, summarizing and discussing the main findings of the reviewed articles, the present review article sought the performance of Iwan as an Islamic architecture element in different climates and its impacts on traditional house comfortability. It also examined the advantages and the disadvantages of Iwan to find out whether or not it still is usable in the present.

In relation to the discussion of the findings, the following conclusions could be drawn:

- Climate is the most influential factor influencing the Iwan's position in dwellings, shape, size, and use; as climate zones vary, so do these characteristics. As a result, it is concluded that the primary function of Iwan is its climatic performance.

- According to the studied articles, it has been concluded that this semi-opened space is still used in traditional cities or in sections of other cities, and majority of Iwan users' comfort with this traditional space.
- Iwan has both positive and negative characteristics; the most positive aspects are directly related to Iwan's climatic factors, while the most negative features are related to other variables. As a result, Iwan's climatic benefits exceed its downsides.

- It has been determined that Iwan is more efficient in hot temperatures, and that this element suffers from controlling the indoor temperature, which mostly impacts cold regions. Using barriers are recommended in Iwan for cold and rainy weathers to regulate indoor comfortability.

- The role of the Iwan is critical, and it varies by changing its orientation and parametric variables. In Sulaymaniyah city-Iraq, the best dimension ratio is a depth to width ratio of 1:1.5 and is oriented south; the worst-case study is a depth to width ratio of 1:1.6 and is oriented to an azimuth angle of 250°.
- The ideal height for Iwan use in any climate is in the southern elevation of a home, and the ideal depth for Iwans in all climates is 1.5 meter, having Iwan with three sides being the best form in all climate types.
- The roof of an Iwan is the most essential architectural component since it can result in a significant drop in temperature.
- The south elevation is an ideal direction for using an Iwan in all climate zones, because it offers the highest rate of thermal load.

Hence, the research questions could be answered: Iwan's utilization advantages outnumber its disadvantages relative to climate performance, and it is still usable in the present-time, and this confirms the study hypotheses

References

Abdulrahman, H. H., Ahmed, A. Q., & Abtar, A. N. (2019). Parametric Studies on Solar Performance of Iwan in Traditional Houses in Sulaymaniyah's old Town. *Sulaimania Journal for Engineering Sciences*, *6*(2).

Eskandari, H., Saedvandi, M., & Mahdavinejad, M. (2018). The impact of Iwan as a traditional shading device on the building energy consumption. *Buildings*, *8*(1), 3.

Foruzanmehr, A. (2010). *Vernacular passive cooling systems and thermal comfort in traditional dwellings in hot dry climates-A case study of Yazd, Iran*. Oxford Brookes University.

Foruzanmehr, A. (2015). People's perception of the loggia: A vernacular passive cooling system in Iranian architecture. *Sustainable Cities and Society*, *19*, 61–67.

Izadpanahi, P., Farahani, L. M., & Nikpey, R. (2021). Lessons from Sustainable and Vernacular Passive Cooling Strategies Used in Traditional Iranian Houses. *Journal of Sustainability Research*, *3*(3).

Kakizadeh, M. H. (2014). Analyzing the fluidity of iwan's space in traditional houses of Bushehr. *Scientific Journal of Review*, *3*(7), 600–608.

Kalantari, N. N. P., Singeri, M., & Jourshari, S. R. (2015). Investigation of the Relationship Between the Climatic Role of Iwan and Rate of Energy Consumption in Traditional Houses of Tabriz. *Procedia Engineering*, *118*, 711–719.

Khalili, M., & Amindeldar, S. (2014). Traditional solutions in low energy buildings of hot-arid regions of Iran. *Sustainable Cities and Society*, *13*, 171–181.

Masoumian, F. (2014). Climatic-Adaptability Solution in Traditional Architectural of Desert Areas of Iran/Kashan. *Advanced Materials Research*, *935*, 18–22.

Nejadriahi, H. (2016). An Investigation on the Role of Iwan as a Sustainable Element in the Traditional Houses of Different Climatic Regions of Iran. *International Journal of Civil and Environmental Engineering*, *10*(7), 871–874.

Shaeri, J., Yaghoubi, M., & Habibi, A. (2018). Influence of iwans on the thermal comfort of talar rooms in the traditional houses: A study in Shiraz, Iran. *Buildings*, *8*(6), 81.