

# Vernacular Residential Architecture in the Context of Sustainability – Case Study of Svrzo's House Complex

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This paper analyses the presence of sustainable elements in one of the most representative surviving examples of vernacular residential architecture from the Ottoman period, located in Bosnia and Herzegovina. The focus is on the significance of vernacular architectural elements, which can serve as an inspiration for contemporary building design in the context of sustainability. Two main aspects need to be considered: respecting the inter-relationship between humans, nature, climate, and local surroundings, and adaptation of design to the time in which it was created. Svrzo's house complex, as National Monument, is chosen as a case study, and detailed survey was conducted regarding the presence of sustainable design principles i.e., building form, use of local materials, orientation, adaptation to local climate and topography, passive cooling and natural-induced ventilation, water, and vegetation. A traditional architectural treasure – a functional, simple, and aesthetically valuable concept, shows that ambient requirements were met with minimal energy consumption and material waste from construction to consumption, achieving a responsible ethical attitude towards the environment. The analysis also includes an evaluation of energy efficiency aspects, by comparing the actual heat transmission values of the building elements with the allowable heat transmission values, prescribed by regulation. The actual average heat transmission values are higher which indicates that although the positive impacts of using natural local materials are wide, in terms of enhancing thermal properties, these sustainability features alone are not sufficient to prevent heat losses without proper thermal insulation.

**Keywords:** contemporary architecture, vernacular architecture, sustainability, environment, thermal comfort.

An important approach that could contribute to promoting and strengthening the human-nature connection in the context of sustainability is through exploring how architecture can contribute to fostering that connection (Kreamer 2022). But surely, it can be challenging, most often because of prejudice that architecture is something that has destroyed many natural environments for the needs of urban settlements, thus leading to the question of how something that takes away natural spaces can again reconnect with them. Based on the dynamics of urban development, cities can be considered as one of the greatest achievements of human civilization, but on the other side, they can also be seen as "humanity's most complex creation" (Kacyira 2012).

One of the indubitable facts that supported such an attitude towards building practice was the global development, characteristic for the 20th century and the past decades of the 21st centu-

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## Abstract

## Introduction



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ry, followed by the strong dynamism of urbanization, modernism, and industrialization processes (Apil 2013; Larena and Larena 2013). Growing demands, technological development, and the needs of modern lifestyle required that contemporary architecture had to respond to it in the modern context, by suppressing the principles, approaches, and practices of traditional builders (Rodman, Lenssen, and Peterson 1995). What has changed is that the construction ideology has led to detachment of the building integration with nature, becoming less engaged and less adaptive to it (Apil 2013). As the urban development was followed by the changes in the cities in the growth of citizens, urban sprawl, and lifestyle demands, the distancing was increasingly noticeable – “the environment at one end” and “the people who receive the finished product at the other”, focusing only on “their immediate, day-to-day concerns”, while massively exploiting the resources without considering the consequences (Rodman, Lenssen, and Peterson 1995).

Such modern urban settlements were representative symbols of modernity, described as “higher than mountains, with roads wider than the sea, yet crowded and congested” (Apil 2013; Rodman, Lenssen, and Peterson 1995). Advantages that the city provided through urbanization and industrialization processes, on the other side, have gradually become a weakness and a burden for cities (Višić 2021), due to the limitation and narrowness of the available space in densely populated urban areas, forcing builders to design buildings at the expense of the local environment and climate. Unfortunately, the result is that the building environment seemed in the end “both physiologically and psychologically inhospitable” (Coch 1998).

In recent years, there has been a significantly increased concern regarding the tempo of modern life, constant reference to energy and climate crises, and the necessity for finding adequate solutions, which have led society to reconsider environmental, energy, and economic aspects of life in the cities (Larena 2022). Due to the continuous needs and considerations of modern life, which differ from the past, traditional lifestyle in many aspects, from social, cultural, to technological, it is clear that the tasks of architects of this time are far more complicated (Serghides 2010). The imperative focus of urban planners and architects should be on identifying aspects that could lead to an increase in the overall quality of the urban environment, contributing to people’s mental and physical well-being (UNEP 2022; Silva 2012).

In this context, “sustainability has emerged as one of the most important and internationally endorsed principles in terms of appropriate building practices” (Tomovska and Radivojevic 2015). Considering that vernacular architecture represents the highest form of sustainable design, defined as “the creation and responsible management of a healthy built environment based on resource efficient and ecological principles” (Tomovska and Radivojevic 2015), it has attracted the interest of numerous researchers worldwide. The aim of the vernacular architectural practices is to regain closeness with nature and recover the lost relationship with the environment, through the integration of traditional practices into modern sustainable building design concepts (Marafia and Sayigh 1998).

Bosnia and Herzegovina (B&H) is one of the countries characterized by its rich architectural heritage. Numerous and diverse architectural monuments, which preserved their characteristics for centuries, are important today for their cultural - historical significance, visually documenting the time, understanding, aspirations, ways and expressions of people’s lives in the past. Consequently, such architectural monuments deserve full attention, especially since vernacular architecture, mostly due to unplanned urbanization, is gradually changing its structure and disappearing (Bejtić 1952).

Therefore, in this paper we analyzed sustainable features of vernacular urban architecture in Sarajevo, the capital of Bosnia and Herzegovina (B&H), focusing on the case of the traditional Bosnian house complex, a significant structure due to its status as a national monument. The following

sustainable criteria of vernacular architecture from the Ottoman period were considered: environmental integration - orientation and location on the site; use of local materials, with minimal energy consumption use, as a responsible attitude towards natural resources; thermal characteristics of materials; optimal and purposeful disposition of the space (internal and external); landscape design of the courtyard (water, greenery, the materialization of the pavement, etc.); the position of the house in order to achieve the right to privacy and the right to an unobstructed sight; passive systems for cooling and ventilation; sunshine protection; and the comfortable ambiance of the entire space. The aim is to estimate if such building design can serve as an example for bridging the gap and establishing a balance between traditional and modern values, by implementing sustainable principles in modern construction in such a way that, with optimal energy consumption, the requirements of thermal and visual comfort are met.

### Significant Features of Vernacular Architecture

The culture and traditions of each region's history were expressed through the design of buildings and remarkable landscapes, witnessing to the heritage that should be preserved and valued (Ferreira et al., 2013).

Vernacular architecture is a sign of the identity and culture of a nation as it follows the local tradition, representing a fundamental characteristic of human civilizations that are sustained and transmitted through practices from one generation to another. The word vernacular originates from the Latin word "vernaculars," or native, domestic or in a broader sense it can be defined as "a type of local or regional construction, using traditional materials and resources from the area where the building is located" (Ghisleni n.d.; Rajković et al., 2022; Turkušić 2011).

The architectural design respects the landscape through the shape and size of a building and its relationship with the environment. Available local materials are being used with traditional technologies. The adaptation to local environmental conditions implied that buildings assumed the identity that reflected the architectural image of each region (Ferreira et al., 2013).

Vernacular housing was created as a result of "adaptations to natural conditions in architectural principles, which emphasized the bioclimatic response to the conditions of the natural environment" (Rajkovic et al., 2022). The origin of the bioclimatic approach in architecture can be traced back to the design principles applied in most traditional buildings all around the world (Nguyen and Reiter 2017). Bioclimatic principles can be recognized in the choice of location, the orientation of the building and its adaptation to topography, the organization of space, the use of local materials, natural wind-induced ventilation, the typology of the settlement, and the integration of greenery into the building design. Following bioclimatic principles in architecture, building designers tend to achieve optimal comfort, using preferably architectural elements, striving to be environmentally friendly, and avoiding complete dependence on mechanical systems. Hence, bioclimatic architecture can be considered as a critical concept for achieving the sustainability of modern buildings (Nguyen and Reiter 2017).

Vernacular architecture, as a true and original means of sustainable design, may serve as a prototype for the future development of residential architecture, by determining the precise criteria as a design guidance (Korjenic and Klaric 2011; Ozorhon and Ozorhon 2014; Tomovska and Radivojevic 2015). This means that all good traditional principles can be transposed into new contemporary models, respecting traditional principles and the existing environment, taking care not to endanger the aesthetic representativeness, meaning that contemporary architecture must be in the spirit of the time in which it was created. (Sayigh and Marafia 1998; Turkusic 2011; Rajkovic and Bojovic 2016).

This approach is supported by the design philosophy, actively propagated today within the framework of sustainable development, which considers three important elements: maximizing the

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## Literature review

quality of the building environment, especially from the aspect of energy efficiency and energy conservation, minimizing the impact on the environment, and giving the attention to human health and comfort (Zr and Mochtar 2013).

Since the transfer of knowledge about the historical vernacular practice for the design of buildings in the future may be difficult to achieve without evaluation, awareness, and sensitivity about it, the importance of studies that review, analyze, and reveal the relationship of traditional settlements with nature, becomes even more evident. (Ozorhon and Ozorhon 2014). Historical experiences should serve as a bridge that connects the past with the future, because “innovation will be impossible without knowing the history”, meaning that “an innovation independent from history will be incompatible with the present time” (Ulusoya and Kuyruk 2012).

### Vernacular Architecture During the Ottoman Period - Sarajevo and Mahalla

The foundations of what is now understood as the Bosnian architectural and cultural tradition, when it comes to residential architecture, originate from the time when B&H was ruled by the Ottoman Empire. Bosnian people appreciated the Ottoman period as it reflected the prosperity and great achievements, perhaps because Sarajevo has formed a specific architectural and residential culture that was the combination of the experiences from the East and the local needs (Zejnilovic and Husukic 2018).

Cities were developed in two zones. One is the bazaar - the center of crafts, trade, and traffic, and the other is the mahalla - the residential area of the city. Čarsija was always in the center of the city, where the roads met from all sides, and the mahalla was always located in a special area, outside the main traffic area (Bejtić 1952). Transition from the čaršija into the mahalla is gradual “as the street becomes tighter and introspective” (Cakaric and Idrizbegovic Zgonic 2019). In this chapter, only the concept of mahalla will be analyzed.

The word mahalla was brought to the Balkan from the Ottoman or Turkish word mahalla, meaning “to settle”, and “to occupy”. Today it is popularly recognized as a neighborhood in large cities and towns. Mahallas lie at the intersection of private family life and the public sphere. It represents a “community of people living in a certain small territory, intertwined with personal ties, a commonality of interests and obligations, and participation in common affairs” (Adilbaevna 2020). What is interesting for mahalla is that all life problems and happiness of people in Sarajevo were being solved in mahalla through mutual agreement. Such a relationship preserved the closeness of the citizens, representing the pillars of the city’s functioning in the Ottoman period, so it is no accident that there was harmony and discipline in life in the city (Garibija 2015).

The mahallas of Sarajevo as residential neighborhoods were developed on the slopes of the mountains surrounding the city when B&H became a part of the Ottoman Empire in the 14th century (Fig. 1). Mahallas can be characterized as peri-urban settlements that are a hybrid of urban conditions with both rural and urban aspects (Peragine 2019). They were in harmony with

topography as they followed the contours of the slope, providing residents with a view, sunshine, and intimacy.

Each mahalla had one main street, with several smaller winding streets, sokaks, branching off on both sides, where were houses with courtyards and gardens (Temim 2013). It usually consisted of 30-40 individual houses. In this period, architecture is dominated by greenery and water, in both utilitarian and aesthetic role, and the urban factor prevails in the entire city area (Temim 2013).

**Fig. 1**

The layout of mahalla on the slope of the mountain in Sarajevo (Đelilović-Malešević 2003)



The arrangement of spaces inside traditional houses in Bosnia and Herzegovina was carefully thought out in order to arrange spaces that would fulfill the conditions of family life in the best possible way. This necessarily included the distinction between private and public areas (Ozorhon and Ozorhon 2014; Hadrovic and Kudumovic 2021). The organization of a typical Bosnian house from the 17th century consisted of five main elements: a high wall that faced the street and had the purpose of distinguishing the private from the public, a courtyard that was usually built of gravel or stone for ease of maintenance, an outdoor fountain (šadrvan) for sanitary purposes, the lower level of the "semi-public" private space, the winter floor, called the hayat where the family would spend time together, and the divanhan, the upper level semi-private/private space, the summer floor, used for relaxation (Ozorhon and Ozorhon 2014).

Every single house in the mahalla was built in such a way that it does not obstruct the view of the neighbor's house, and the place was carefully chosen to provide the best possible view of nature and the surroundings. The houses were therefore placed on the slope, gradually, to allow each other a free view of the valley, as shown in Fig. 2 (Bejtić 1952). The position of houses in accordance with the terrain on which they were built, shows that the houses are perfectly integrated into the environment. The features of buildings were influenced by the characteristics of a place, culture, and local climate (Correia, Dispasquale, and Mecca 2014, p. 43).

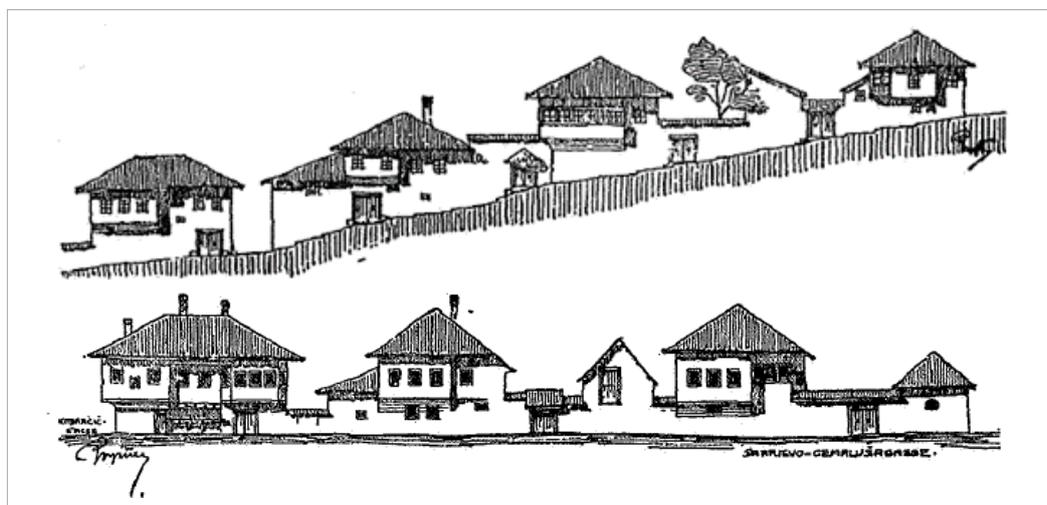


Fig. 2

Vertical displacement of houses - "the right of a view (vista)" - top picture; Placing a house on level ground - bottom picture (Bejtić 1952)

In general, the most important rules in the arrangement of the mahalla, according to Bosnian traditional principles, which are considered to be the unwritten rules of construction, were the right to a view and the right to privacy, as a norm that in the past, but also today, represents high-quality housing (Simonović 2022). Famous modernist architect Juraj Neidhardt respected and adopted these rules in the urban development of Sarajevo in the 20th century, as it is explained in (Simonović 2022), by "the selection of the location of buildings in such a way that tall ones remain in the valley, medium-sized ones are on gentle slopes or hills, and low ones on steep slopes". Where the configuration of the ground did not allow free views, this was solved in such a way that the houses were positioned horizontally so that a bay window on the first floor ensured a free view' along the entire street (Bejtić 1952).

The design of the houses was primarily conditioned by the location. Consequently, each design was different in layout, but similar due to the identical materialization and formative motives. Environmental compatibility of traditional Bosnian individual houses was established by using local materials, respecting climate, and meeting residents' needs (Halilovic and Berkovic 2021). The utilization of easily procured local natural materials and the features of these materials serve to support and enhance this approach (Ozorhon and Ozorhon 2014).

**Fig. 3**

View of the sokak in the mahalla, surrounded by high, white walls – Sarajevo (Đelilović-Malešević 2003)



The residential buildings are bounded by high, white walls, which enable the creation of an intimate space for the family to stay (Fig. 3). The walls were not solely in the function of separation, they had the role of „the earth - sky“ connection - the house was opened to the sky through the courtyard, providing the unobstructed view in all its part (Temim 2013).

The need to ensure privacy from street emphasized, even more, the need to create a more comfortable and natural environment for living. The entire complex, in an architectural

sense, represents a harmonious combination of greenery and buildings, with the aim of creating an intimate family life. In the Ottoman period Sarajevo did not have public parks and there was no need for them. Each house had its own intimate gardens and spacious courtyards, where a variety of fruits, vegetables and flowers were grown. According to (Bejtici, 1952) „home gardens gave the whole city a garden character“ as the tree branches and various flowers lushly spilled over the walls surrounding houses and alleys. Besides the environmental comfort role, the advantages of the open spaces in the form of courtyards were reflected through social interaction, open spaces were intended for gathering, socialization, and social activities.

Wherever the possibilities existed, the local man tended to build a house near running water. And even where he could not build a house near the river, he found a way to provide water in the courtyard. Every house had a fountain with a stone trough and a drainage channel, through which the water bubbled, creating a natural and comfortable atmosphere. The presence of water was important because of two reasons. One is the sanitary needs, to which a lot of attention was paid, and the other is the desire to enjoy the freshness and the noises of the running water. This was possible because the cities of B&H are rich in running and spring water (Bejtić 1952).

The design of the house is characterized by cubic form, slightly sloping roof covered with hollow tiles, unornamented walls, loggias, verandas, courtyards and doksat on the upper floor that rises above the street, creating a rich and dynamic facade. Wood, stone, and adobe brick were the primary materials of B&H architecture of the Ottoman period (Bejtici 1952; Korjenic and Klaric 2011). The domestic architecture used stone mainly as a structural material, and almost negated stone as a decorative material, covering it everywhere with plaster. Adobe bricks were preferred material compared to the stone, as the transportation and processing of stone required much more effort and expenses than the production of adobe bricks, which was performed near the construction site. Wood retains its natural appearance and structure everywhere, as a constructive element and architectural decoration. Therefore, it has constructive and decorative meaning at the same time (Bejtić 1952).

Until the end of the 19th century, Sarajevo was known for the quality of its architecture and the beauty of the surrounding landscape (Peragine 2019). Even today, in most cities in B&H, certain parts of the cities have a clearly expressed oriental physiognomy due to their architectural and urban planning characteristics. In these cities, the largest number of preserved architectural monuments belong to the classic Ottoman style (Bezdrob 2002).

### **Contemporary Architecture in Sarajevo in Relation to the Vernacular Tradition**

In the middle of the 20th century, B&H experienced significant industrial development that resulted in rapid urbanization. Population growth and the need for financial security through the search for work have led to greater immigration of people to urban areas. Although urban development took into account the nature of the terrain and the landscape, the regulations were largely ignored

due to the enormous demand for housing (Peragine 2019). The worst period in this sense was in the 60s and 70s of the 20th century when new construction technologies and economic development resulted in a huge number of residential buildings that were built without awareness of the environmental impact.

The worst situation was in the suburbs of the city. The houses were built from reinforced concrete in combination with brick and often with an unfinished facade (Peragine 2019). This building trend has continued to this day. Today, Sarajevo attracts interest for significant investments, which leads to increased urban development, and as a result, architecture is built without following the community values that were once established. Studies that were implemented with the aim of improvement of the energy efficiency of the building sector in B&H, have shown that most buildings were characterized by poor or non-existent thermal insulation, dilapidated wooden windows on older buildings, poor quality of newly built buildings, inadequate heating systems, massive use of traditional, cheaper fuel such as coal and wood (Klarić et al. 2016). Internal migrations and the growth in the population have led to a massive increase in the number of dwellings (Fig. 4), very often causing illegal construction on unstable terrain and riverbanks, disregarding the natural context.

Unsustainable urban planning, which in a certain way is considered to be uricide, significantly contributes to environmental pollution (emission of greenhouse gases, air pollution, and noise) of the city. Authentic vernacular Sarajevo urban settlements are gradually disappearing, or they have lost their identity (Berković and Halilović 2021). These are all

factors that have led to an extremely unfavorable situation, which affects the quality of life of all citizens of B&H (Klarić et al., 2016).

In Bosnia and Herzegovina, as well as in many countries of the world, the building sector from the aspect of energy efficiency, is one of the sectors with the greatest potential for sustainable, comprehensive development. In general, the activities in this sector are focused mainly on the goals related to the reduction of the required energy for heating, cooling, and ventilation, and at the same time, a very important factor related to improving the quality of life was neglected. As mentioned earlier, through the vernacular practices of *neimar* (an old name for an architect or builder) in the use of local, natural materials, one of the priorities of energy efficiency projects must be raising awareness of the use of non-toxic materials in any segment of the life cycle of that material (Klarić et al. 2016). Therefore, it is necessary to carefully consider the impact on the environment and natural resources by designing construction solutions that are environmentally acceptable, sustainable, and in accordance with the needs and requirements of the time in which they are created.

In Bosnia and Herzegovina, the enormous potential for solving urban challenges today is an example of rich local traditional construction, natural sustainable materials, resources, and existing infrastructure, which can represent the strength of the future sustainable development of this country (Klarić et al., 2016).

### Examples of Bioclimatic Aspects of Traditional Architecture Interpretations in Modern B&H Architecture

Sustainable practices of vernacular architecture serve as an inspiration and a guiding idea for today's architects. Successful examples of this approach to building design do not just copy tra-



Fig. 4

Illegal residential construction in Sarajevo (Bubalo 2017)

ditional styles but transpose the positive characteristics of vernacular architecture into a contemporary form. A good example of design and construction based on sustainable principles of traditional architecture, but through a new contemporary design, is a private complex object in Bijača, B&H. Sustainable principles, inspired by vernacular architecture, which can be recognized in this example are the use of locally available limestone as a building material, the location of each house within the complex in such a way that it does not obscure the view of the neighbor's residential unit, the building of the house in accordance with the topography, and the stonework that revive the traditional way of local construction. The roofing material in the Herzegovina province is slate slabs, which are used for two reasons - one, due to the lack of wood, and the other, due to the strong winds that prevail there (Bejtić 1952). In terms of form and aesthetics, the white asymmetrical concrete window frames are reminiscent of the old white stone window frames that are characteristic of the Herzegovinian folk Mediterranean houses (Kosanović et al. 2018), as shown in Fig. 5.

**Fig. 5**

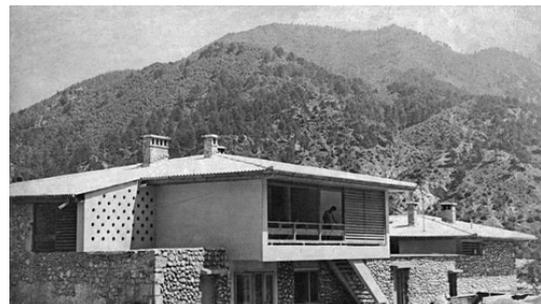
Vernacular house in the Old Town Počitelj - left; Contemporary house within the private complex in Bijača - right (Omanović D. 2020; Les R. 2011)



Another good example of a neo-vernacular house perfectly adapted to the natural and traditional environment is the Family House in Konjic, which was built in 1952 by the famous architect Andrija Čičin-Šain (Museum of city Rijeka 2009). The vernacular elements in this contemporary reinterpretation design can be seen in a form of a doksat, a characteristic element of oriental architecture, which represents the projecting part of the house, giving the impression that is "floating" above the street (Fig. 6). The house has distinct horizontal cubic form, a sloped roof, and the ground floor is made of local stone brought from the nearby river Neretva. As the aforementioned traditional practices, the house is surrounded by courtyard walls and protected from external views. The windows facing the street, have specific sun protection elements that represent a stylized form of traditional mušebak (Fig. 7). Mušebak is a specific creation of oriental culture, created as a special network of wooden slats, and it has mainly symbolic meaning: ensure visual communication from the private part to the public and prevent visual communication from the public to the private part (Hadrović 2022 p. 9).

**Fig. 6**

Vernacular Ivo Andrić's birth house in Travnik - left; Contemporary Family House in Konjic - right ("Ivo Andrić's Birthplace" Memorial Museum n.d.; Museum of city Rijeka n.d.)



**Fig. 7**

Traditional mušebak - left;  
Stylized form of traditional  
mušebak – right (Authors  
2022; Museum of city  
Rijeka n.d.)

The aim of this research is the analysis of vernacular residential building from the aspect of sustainability and good architectural practice, pointing out the importance of integrating vernacular architectural elements in the context of inspiration for designing sustainable contemporary buildings. The conducted analysis can be divided into two parts.

The first part consists of a literature study and field observation. The study literature included the research of data on typical characteristics of vernacular residential architecture in Bosnia and Herzegovina. For the analysis, as a case study, well-preserved, famous vernacular residential house complex, Svrzo's house complex was chosen, located in Sarajevo, B&H. Its importance is reflected in the fact that it is one of the oldest preserved examples of Sarajevo residential architecture from the 17th century, and is considered a jewel of Ottoman residential architecture. Field observation included direct field research of construction, building layout, and materialization of the selected house. For the selected subject of the study, which is based on complementary data and layout designs obtained by observation and recordings at the location of the site and study literature, a detailed investigation was carried out on the presence of the principles of sustainable design.

The second part includes an analysis of the energy efficiency of the envelope of a selected residential building, with the aim of assessing the possibility of achieving adequate thermal comfort in the context of energy-responsible design. The aim is to investigate whether the construction of the building envelope meets today's standards of energy efficiency and whether it can be used as a prototype for contemporary design.

The analysis of vernacular architectural elements from energy and architectural aspects can be the basis for the transformation of perspective and awareness of the importance of harmonization and integration of vernacular practices into contemporary architectural and energy design. In other words, the goal is to design a structure based on the strategies of vernacular sustainable principles – an architectural design that included environmentally friendly, natural elements, low energy requirements, and improved inner comfort conditions (thermal, indoor air quality, acoustic and visual), while meeting contemporary needs.

### **Analysis of the sustainable features of Svrzo's house complex in Sarajevo**

In this paper, Svrzo's house complex in Sarajevo will be analyzed, as one of the most authentic examples of residential architecture of the Ottoman period in Bosnia and Herzegovina, which has survived to this day.

The analysis of the various sustainable elements of Svrzo's house complex includes the research of the following characteristics:

- \_ Location on the site;
- \_ Building form, space composition, and orientation;
- \_ Local building materials and construction;

## **Research methodology**

## **Case study**

- \_ Thermal efficiency and thermal comfort;
- \_ Traditional methods of cooling and natural ventilation;
- \_ Traditional methods of sun protection;
- \_ Courtyard, and elements of vegetation and water;
- \_ Pleasant and comfortable living environment.

The bioclimatic design of buildings, as one of the strategies for achieving sustainability, contributes to energy consumption reduction by adapting buildings to the local climate conditions. Natural environmental sources such as sun, air, wind, vegetation, and water are used for passive heating, cooling, and natural lighting (Rahim 2022). Location on the site, building form, space composition, and orientation of the building, have a significant impact on energy consumption and internal comfort. The position of rooms and openings have to be in accordance with “the requirement for sunlight” (Matolcsy et al., 2015). Maximum use of daylight and the provision of natural ventilation is recommended as a passive way of heating and cooling. (Ozarisoy and Altan 2012).

Important elements of passive cooling are sun-shading elements and natural vegetation. These elements are related to the building orientation. According to (Matolcsy et al., 2015), “west and south facades of buildings are ideal orientations for implementing solar access control, such as shading devices in the form of arcaded terraces, verandas or balconies.” Natural vegetation can be used as an additional solar shading element, and the presence of water additionally contributes to lowering the temperature in courtyards during the summer, creating a pleasant microclimate.

One of the passive strategies of bioclimatic architecture which also contributes to the achievement of “satisfactory microclimatic conditions and certain internal comfort” with the above-mentioned criteria, is the color of the building facade and surrounding surfaces (Convertino, Turi, and Stefanizzi 2017). The color of the external surface layer has an impact on environmental comfort, in a way that during the summer period, the adequate color of the facade could reduce solar gains, and during the winter period, it improves solar gains. From the aspect of Urban Heat Island (UHI), as a major global urban problem, some of the recommendations for reducing the UHI effects are the use of building materials that are less-absorptive and natural, lighter-colored surfaces, passive systems for cooling and ventilation, water and green spaces, nowadays in the form of green facades and roofs (EPA 2022; Waldrop 2022).

In the context of sustainability, the selection of appropriate building materials is very important. An important requirement that should be taken into account is using local materials, as their use is beneficial if there is a tendency to minimize energy consumption in the processes of extraction, manufacturing, and transport (Ozarisoy and Altan 2012). From the environmental aspect, the focus should be on the selection of materials that are (Matolcsy et al., 2015): “natural and plentiful; not pollutant, with low embodied energy and carbon dioxide emission; renewable, recycled or recyclable in order to minimize waste and to extend life cycle; and with high energy performance.”

### **Building Location**

The construction of Svrzo’s house complex began in the 17th century, and it was finished in 1832 when an additional single-story house was built. The Commission to Preserve National Monuments designated Svrzo’s house complex as the National Monument of Bosnia and Herzegovina. Svrzo’s house complex is located in a street (mahalla) that managed to preserve its most authentic appearance. The house complex was built by the Glodo family, but later the Svrzo family became the owner, and they sold the house to the Sarajevo Museum in 1952, which was then adapted into the museum. Svrzo’s house complex was built on “a human scale”, and in a way not to obstruct the views of the neighbor’s residential units. The house fits well into the terrain and it is in perfect harmony with the environment of the mahalla (Fig. 8 and Fig. 9).

Taking into account the architectural experience of the space in this vernacular residential example, where the combination of nature and architecture is a significant dimension of the era in which the house was built, two sequences play an important role in the perception of space - the access or entrance sequence and the internal sequence. The entrance sequence has the task of making the visitor interested in the object, representing the physical boundary between the built and unbuilt environment, while the interior sequence defines the interior of the architectural object (Trapara 2016). The modest appearance of the house from the street, but the rich decoration of the complex from the inside, represents the life story of the residents who lived in this house where luxury was not priority to them, but their own enjoyment and family life. The entire complex was built exactly according to the life needs of that time (Trapara 2016).

From the street, the house blends into the ambiance and forms an integral part of the mahalla. For the visitor who comes to this part of the city for the first time, the house is hidden, and protected from the outside views by high, white walls, with a characteristic courtyard door and a protruding dock (Trapara 2016).

The utilization of microclimate elements such as wind, local breezes, sun, vegetation, and water together with the creativity of the architect, very often led to an inspiring architectural design, as can be seen in the example of Svrzo's house complex. (Trapara 2016).

Svrzo's house complex, conceptually, is an important part of the heritage of Bosnia and Herzegovina. Morality, philosophy of life, relationship to family and neighborhood, vegetation, water, and life guidelines, were all "woven" into a harmonious spatial structure. (Salihbegović 2012).

### Building Form and Orientation

The spatial concept of the house complex demonstrates division in a horizontal and vertical sense. In a horizontal sense, the residential complex was divided into two parts, the women's quarter called haremluk, and the men's quarter called selamluk, with belonging men's and women's courtyards. These courtyards are connected by two gardens, forming a harmonious unit. The green areas of the courtyards, in the Ottoman period, represented a creative expression in landscape design, a combination of traditional and oriental-Mediterranean influences (Temim 2013). The courtyards were always cobbled (Fig. 10).



Fig. 8

Location of Svrzo's house complex and surrounding houses, Sarajevo (Google Earth Pro)



Fig. 9

Entrance to Svrzo's house complex from sokak (Trapara 2008)

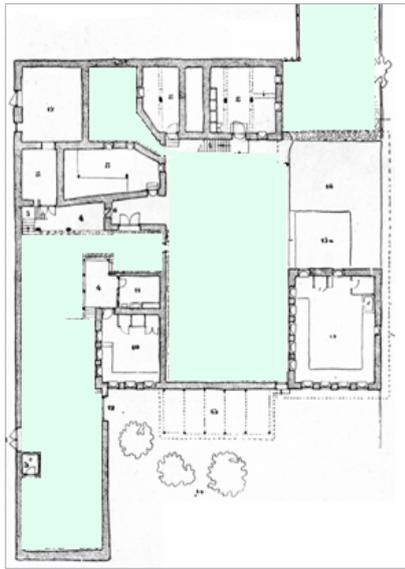


Fig. 10

Woman's courtyard in Svrzo's house complex (Authors 2022)

Fig. 11

Svrzo's house complex – courtyards and gardens forming a harmonious unit (Salihbegović 2018)



The cobblestones were comfortable to walk on, and they had a very important role in maintaining hygiene (Temim 2013). In both courtyards, there were fountains with a stone trough and a drainage channel through which water bubbled, creating a pleasant atmosphere. The arrangement of the residential complex, through a harmonious combination of greenery and buildings, created a more comfortable and healthier environment for living, while at the same time ensuring the intimacy of family life (Temim 2013).

The concept of the house with courtyards, gardens, greenery, and fountains, represents the integration of bioclimatic elements into the design. The layout of the gardens and courtyards is shown in Fig. 11, marked in green solid color.

In a vertical sense, the main part of the house complex is divided into the winter quarter located on the ground

floor, and the summer quarter located on the upper floor (Fig. 12). The men's and the women's quarters on the first floor are interconnected via narrow wooden corridor called the mabejn, kubura or araluk. That part in relation to the men's and women's house can be considered as an entrance sequence, and in relation to the complex, it is an internal sequence that leads a visitor to a more intimate space - the women's courtyard on the ground floor, and the women's part of the house on the upper floor, haremluk (Trapara 2016).

Fig. 12

Svrzo's house complex, left - ground-floor plan, right - first-floor plan (Authors 2022)

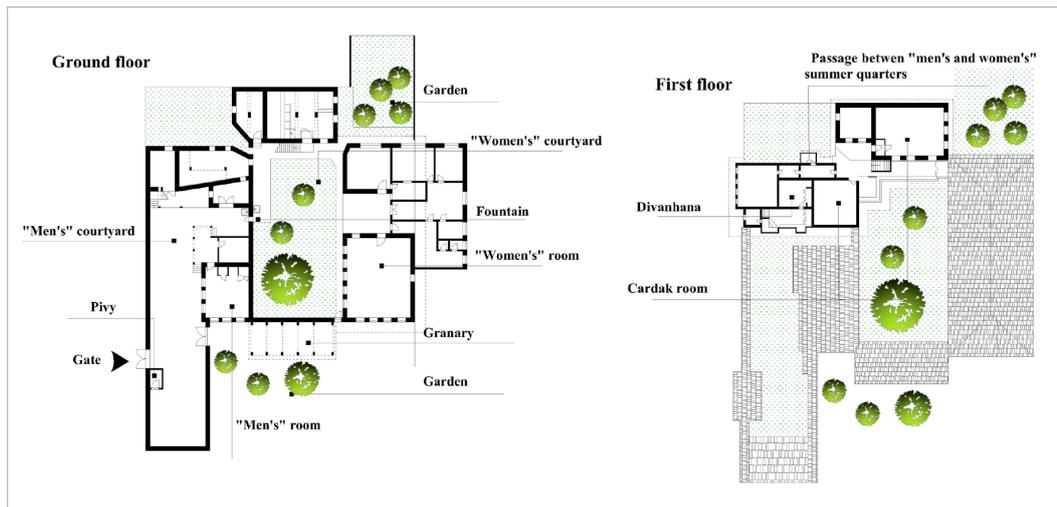


Fig. 13

Kamerija in the woman's part of Svanzo's house complex (Authors 2022)



The semi-closed space in the women's quarter, called divanhana is oriented towards the south, facing the women's courtyard, and the other semi-closed space, called kamerija (Fig. 13), is oriented towards the south and east.

The windows in the main first-floor room, čardak, are oriented towards the south and east. The small room, called čardačić, has windows on the west wall and one on the south wall. In the men's quarter of the main house, windows

are facing west and south. On the east part of the men's courtyard, a separate single-story building called musafirhana is located. Musafirhana was used as accommodation for male visitors and is oriented towards the west and south. On the east side of the women's courtyard, there is a single-story building, known as young women's house. Most windows in this part of the house are west and south-oriented. Only one window is facing north.

This detailed analysis shows that the house was oriented towards the south, west, and east in order to perceive sunlight during the day. Openings that are facing north are minimized, with the aim to reduce heat losses during the winter period.

### Used Materials and Construction

The ground floor is placed on quarry stone foundations, which are merging into the plinth. The walls of the ground floor are made of adobe and reinforced with tie beams. The walls are plastered on both sides and whitewashed with lime milk. The walls of the ground floor are relatively massive in order to ensure the bearing of the first floor and the roof.

The external walls of the storerooms on the ground floor are made of quarry stone. The external walls of the first floor are thin, light, and with lots of windows. The walls are half-timbered, with adobe infill. The ceilings are made of half logs filled with clay, and some parts of the construction are made of wooden joists. The joists are supported by oak beams and wooden pillars with stone bases.

On the west, the street-facing wall in the men's part of the house, has a room with doksat, a protruding part of the house (Fig. 14).

The floors are made of deal planks. The roofs are sloped and consisted of a wooden roof frame covered with hollow tiles (Commission to Preserve National Monuments 2004). For the protection of wooden elements from decay and fungi, smoke was usually used (Halilović and Berković 2022).



Fig. 14

Doksat in Svrzo's house complex (Authors 2022)

Based on the construction analysis from the sustainable aspect, it can be concluded that the materialization of the construction was based on the usage of natural materials from nearby locations, such as adobe, stone, and wood, which are non-toxic and biodegradable materials with low environmental impact.

### The Analysis of the Envelope Thermal Characteristics

The heat transfer in the building envelope is the most important indicator used to describe the thermal properties of buildings and the overall energy efficiency of buildings. Heat losses through the building envelope occur due to the temperature difference between the indoor and outdoor air. The heat transmission through the structure depends on the installed materials, their thickness, and thermal conductivity. The heat transmission affects annual the energy requirements of the building and has a significant effect on overall thermal comfort. The heat transmission (U-value), based on BAS EN ISO 6946 standard can be calculated as:

$$U = \frac{1}{\frac{1}{h_{ci}} + \sum \frac{s_n}{k_n} + \frac{1}{h_{co}}} \quad (1)$$

U - overall heat transmission coefficient (W/m<sup>2</sup>K); s<sub>n</sub> - the thickness of layer n (m); k<sub>n</sub> - the thermal conductivity of the material in layer n (W/mK); h<sub>ci</sub> and h<sub>co</sub> - the convective heat transfer coefficients, inside and outside (W/m<sup>2</sup>K).

Inside and outside convective heat transfer coefficients have been determined empirically ( $h_{ci} = 8,0$  W/m<sup>2</sup>K,  $h_{co} = 23$  W/m<sup>2</sup>K).

In this research, the elements of the building envelope were classified into six categories: outside walls, floors, ceilings above the outside air, ceilings below the unheated attic, floors over unheated space, and transparent and nontransparent parts of the facade (windows and doors).

The average values of the heat transmission of the elements of the building envelope and the allowable heat transmission of building elements of the envelope are shown in Table 1. According to the Rulebook on minimum requirements for energy performance of buildings (Official Gazette FB&H 81/19), the allowable heat transmission of building elements of the envelope is defined in relation to the average monthly temperature ( $\Theta_{e,m}$ ) of the coldest month of the year.

By comparing the actual heat transmission values with the allowable heat transmission values, the degree of fulfillment of these properties in a relation to the requirements prescribed by regulations is determined. The actual average heat transmission values are higher than the allowable heat transmission values for all building envelope elements which indicates that the minimum requirements for the energy performance of buildings are not met. It shows that, although the positive impacts of using natural materials such as wood and adobe are wide, in terms of enhancing thermal properties, these sustainability features are not sufficient enough to prevent heat losses without proper thermal insulation.

### Thermal Comfort

The ground floor was intended for living during the winter. The thick adobe walls of the ground floor are ensuring good heat accumulation and stationary flow of water vapor in the parodifusion process, as can be seen in Table 1, which is a very important factor during the winter period (Hadrović 2022).

**Table 1**

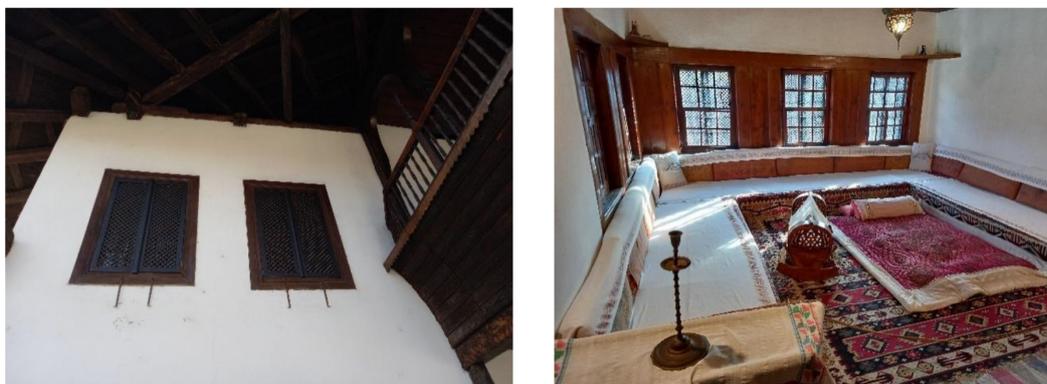
The average values of the heat transmission of the building envelope and the allowable heat transmission values

Construction	Materials	Thickness (cm)	U-value (W/m <sup>2</sup> K)	Allowable U-value (W/m <sup>2</sup> K)	Diffusion resistance, S <sub>d</sub>
The exterior adobe brick wall	Adobe brick	64.00	0.70	0.35	Satisfied
Skeletal wall with adobe brick infill	Wooden skeleton, Adobe brick infill	22.00	1,72	0.35	Satisfied
Ground floor construction	Wooden floor, stabilized loam	45.50	0.97	0.40	Satisfied
Doksat construction	Wood	98.00	0.26	0.25	Satisfied
Ceiling construction towards the attic	Wood	36.00	0.59	0.25	Satisfied
Windows	Wood, single-glazed			U = 5.00 W/m <sup>2</sup> K U <sub>allowable</sub> = 1.40 W/m <sup>2</sup> K	Unsatisfied
Doors	Wood, massive, solid			U = 3.00 W/m <sup>2</sup> K U <sub>allowable</sub> = 2.00 W/m <sup>2</sup> K	Unsatisfied

In the past, the adequate thermal mass of walls was an important element used to minimize temperature oscillations and to protect the rooms from external cold. The well-absorbed heat from the solar radiation in the adobe walls during the day was slowly released into the environment during the night, which provided a continuous pleasant indoor climate (Gallo 1998; Matolcsy et al. 2015).

On the ground floor, the windows are smaller than the windows on the upper floor and oriented towards the inner courtyards. Smaller windows also contribute to heat loss reduction.

The first floor was intended for living during the summer period. Therefore, the external walls are thin, and light, with lots of large windows, which creates ventilated and comfortable living space. Lightweight walls are also providing fast cooling during the night. Large windows are ensuring lots of natural light inside the space, but at the same time, sun-shading elements called *mušebak*, prevent overheating of the room during the summer. *Mušebak* (Fig. 15) can be considered as a vernacular version of a modern double-skin facade, in terms of quality and pleasant ambiance (Salihbegović 2018). In the space between two wooden membranes, due to a shade and lower temperature, airflow is established, and solar radiation is reduced. The semi-transparent cover provides optimal lighting, changing views of the landscape, and the desired privacy.



**Fig. 15**

*Mušebak* in Svrzo's house complex; outside view - left, inside view - right (Authors 2022)

Sun shading of the first floor is additionally provided by roof eaves. Windows also have iron window shutters (Fig. 16). Their purpose was mainly to secure house from intruders during the night, but they could also be used to keep the space from bad weather conditions such as strong winds, prohibiting the entrance of cold or hot air, or too intensive solar radiation during summer.



**Fig. 16**

Passageway elements in Svrzo's house complex; roof eaves - left, iron window shutters - right (Authors 2022)

The ground floor, which is drawn inside, gets sun shading from the overhanging first floor. According to (Ozarisoy and Altan 2021) "the *doksat* provides appropriate shading for pedestrians and for indoor occupants." According to (Philokyprou and Michael 2012), "streets are very narrow, surrounded by one or two-story dwellings that provide shade to passersby."

During the winter, thermal comfort was hard to achieve by using a fireplace, which was the only heat source back in the day. Although adobe walls are considered environmentally friendly, they also have disadvantages, mostly during the winter, due to high U-value, as can be seen in Table 1, leading to more energy needed for heating. Therefore, in order to use this type of material in modern constructions, thermal advancements of building envelope elements are necessary.

From this analysis, it can be concluded that thermal comfort was partially achieved, and more thermal comfort was achieved during the summer than during the winter period. Lightweight walls, large windows, and sun-shading elements are providing a pleasant climate during the summer.

The division of the house in winter and summer quarters, as an energy-efficient spatial organization, could be transposed into contemporary architectural design, in order to reduce energy consumption in both winter and summer periods.

### Natural Ventilation and the Purpose of Courtyards in Indoor Air Control

Natural ventilation is achieved through careful disposition and sizing of the windows in order to achieve cross ventilation through the opening windows at the same time over the house during the summer. Wooden lattice elements also have a role in allowing unobstructed airflow, while at the same time, they prevent overheating of the space.

Porches and verandas, as an integrated part of the house that serve as transitional spaces from interior to exterior, have a significant impact on microclimate improvement. These spaces have good cross ventilation and modify the amount of sunlight that enters the house. The sun protection is provided by deep roof eaves. Therefore, semi-closed spaces, *divanhana*, and *kamerija* were often used during the summer, usually for serving dinner, especially when guests were coming.

Fig. 17

A ventilation opening in the outside wall of the storeroom in Svrzo's house complex (Authors 2022)



On the ground floor, natural ventilation is not as efficient as on the upper floor due to few smaller windows. The storeroom called *magaza*, where the food was kept, has baked clay pipes built into the walls above the ground level, which help to ventilate the walls and to prevent moisture from rising into the upper parts of the walls. Besides these pipes, natural ventilation is achieved through ventilation openings located in the outside walls of all auxiliary rooms (Fig. 17). The kitchen has ventilation openings in the roof to allow the smoke from the fireplace and steam from cooking to escape.

The courtyards and gardens, as green oases with lawns, flowers, trees, fountains, and cobbles, represent the key elements in the process of natural cooling of the building during the hot summer days. According to Sullivan, "the courtyard integrates a wide variety of passive devices into

its design, each creating its own thermal environment" (Philokyprou and Michael 2012). The presence of water elements in the courtyard, together with vegetation, can have a positive impact on the microclimate, especially during the summer period, by providing evaporation and a decrease of temperature by 2-4 °C (Matolcsy et al. 2015). When considering the vegetation refreshing effect, it is reflected through temperature mitigation, solar radiation reduction, increased air humidity, wind mitigation and "regulation" of its direction to improve natural ventilation (Gallo 1998). The main difference between refreshing effects from vegetation and from structures built by a man is that an inorganic material has a limited refreshing capacity, based on the thermal characteristics of that material, and a plant, on the contrary, is a living organism that will regulate most of the solar radiation.

This type of courtyard house is designed in a way that ensures that building envelope surfaces are introverted and oriented towards climate-controlled courtyards (Fig. 18). Such orientation underlines „the importance of the courtyard with regard to the ventilation and cooling of individual rooms" (Philokyprou and Michael 2012).

**Fig. 18**

Integration of the greenery in Svrzo's house complex; small garden - left, men's courtyard right (Arslanagić n.d.)

The benefits offered by an open space in a building are universal patterns, interwoven with beauty and comfort, representing a harmonious relationship with nature (Gallo 1998). Designed as a multifunctional space, in a way to meet the requirements of thermal and visual atmosphere with optimal energy consumption, it also becomes a key architectural element of sustainable construction. The concept of a house with a courtyard, massive ground walls, a vertical layout of the space, and orientation, can represent a solution for accumulation of the heat during hot, summer days and serve as protection from stormy winds (Salihbegović 2018). The facade is painted white, both inside and outside. Besides the light-colored facade, the wooden elements of the building, various shades of flowers and tree fruits, and white-grayish cobblestones in the courtyards (Arslanagić n.d.), together are contributing to the naturalness and comfort of the entire environment. From this analysis, it can be concluded that natural ventilation, as one of the important sustainable elements, is obtained through the careful disposition of windows, the use of sun shading elements that are allowing unobstructed airflow, semi-open spaces (kamerija, divanhana), and projecting part – doksat. Bioclimatic natural elements, such as courtyards, gardens, and water fountains, have a positive impact on the microclimate during the summer, and at the same time, deciduous trees, planted in gardens and courtyards, are not obstructing sunlight and heat inflow from the sun during the winter. The white color of the building facade reduces solar heat gains and prevents overheating of spaces in the summer quarters of the house complex. All these elements participate in the process of regulating the indoor climate during the summer, and as protective tampon zones during the winter.

Increased urban development and unsustainable urban planning represent major problems in urban areas in B&H today. Therefore, finding solutions for building with low impact on the environment is a necessary approach, and providing inspiration from vernacular architecture might be a method for solving increasing problems in urban areas, such as lack of care for the environment, low-quality and energy-inefficient construction, misuse of natural resources, urban heat island, and environmental (air and noise) pollution.

Based on the analysis of Svrzo's house complex, as one of the most representative surviving examples of vernacular residential architecture from the Ottoman period, it can be concluded that sustainability was an integral part of vernacular residential buildings in B&H. The exceptional craftsmanship of old builders, neimars, their understanding of people's needs, and their responsible attitude towards the environment, is reflected in the harmonization of the building's design with the natural conditions of the location. Sensitivity, effort, and knowledge are reflected in practical integrated solutions, harmonized with the natural environment, and with a deep respect for the neighborhood and the need for privacy.

## Discussion

Greenery was an inseparable part of the house concept, where courtyards and gardens formed a harmonious unit with semi-closed spaces of the house. The building was integrated into a natural environment, creating a pleasant and harmonized environment for living. Elements of water in a form of fountains and wells were inseparable parts of the courtyards and gardens. Orientation, building form, and openings were carefully designed, taking into account passive solar heating during the winter period, and protection from intense solar radiation during the summer period. Respect and responsible attitude towards the environment were expressed through the usage of natural materials from nearby locations, such as adobe, stone, and wood, which are non-toxic, biodegradable materials with low environmental impact.

Vertically, the house was divided into a winter and summer quarter, thus achieving an energy-efficient spatial organization in order to reduce energy consumption in both winter and summer. The use of thick adobe walls in the winter part of the house ensured a good heat accumulation and stationary flow of water vapor in the parodiffusion process. Thin and light walls in the summer part of the house allowed fast cooling overnight, and in combination with achieved natural ventilation through the use of a large number of windows, it was possible to provide a comfortable living space. Natural ventilation was achieved by applying architectural elements that had an important role in the regulation of the indoor climate, such as careful disposition of windows, sun shading elements which were allowing unobstructed airflow, and the combination of semi-open spaces with open spaces, like courtyards with greenery and water elements.

The analysis has shown that, in addition to all positive aspects of vernacular architecture, there is also a need for additional improvements in terms of the thermal properties of the building envelope. The calculated average heat transmission values are higher than the allowable heat transmission values for all building envelope elements, which indicates that the minimum requirements for the energy performance of buildings are not met. It shows that, in terms of enhancing thermal properties, it is necessary to pay attention to the optimization of the thermal quality of building envelope elements.

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## Conclusion

The sustainable aspects, recognized in the analyzed vernacular house, represent a good guide in which direction contemporary architecture should go in their materialization and positioning of buildings, regarding the specifics of the location and with respect towards nature. Adapting all the positive features of vernacular buildings and implementing them into contemporary architecture, can result in sustainable modern architecture, through the combination of modern construction standards with bioclimatic elements such as local and natural building materials, orientation, location, building form, passive systems of cooling and heating, greenery, and water. This approach would create a healthy, comfortable living space that evokes pleasant feelings in people, and at the same time decreases the negative environmental impact, which is a major problem nowadays.

This example of Bosnian residential architecture shows that the holistic approach to urban settlement planning was considered even in the 17th century, as an “unwritten” building rule, with adaptive design and adaptability to climatic and cultural context, by respecting residents’ culture, tradition, and habits. A sustainable approach, based on these vernacular architectural principles, can be considered as a heritage of reconciliation that can help to bridge the gap between tradition and modernity, resulting in an integrated urban form that would meet the main area of concern - energy, environment, and comfort.

A proposal for future research will refer to the research on the application of this vernacular house design for the elaboration of the concept of a modern residential building in accordance with sustainability criteria. Since the results showed that the actual average heat transmission values are higher than the allowable heat transmission values for all building envelope ele-

ments, further research will analyze the possibility of improvement of buildings' thermal characteristics, through the application of an optimal combination of energy efficiency measures, using local natural building and thermal insulation materials with low embodied carbon, and energy-efficient windows.

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