ANALYSIS OF VERNACULAR ARCHITECTURE IN TERMS OF SUSTAINABLE CONSIDERATIONS: THE CASE OF ŞİRİNCE VILLAGE IN WESTERN TURKEY

Halıcıoğlu*, F.H

Department of Architecture, Faculty of Architecture, University of Dokuz Eylul, 35160, İzmir, Turkey

*Corresponding author: hilal.halicioglu@deu.edu.tr/ hilalhalicioglu@gmail.com

ABSTRACT

The growing awareness of sustainable building's potential to positively impact environmental issues pushes vernacular architecture to the forefront in order to understand of how to apply sustainable considerations to buildings. Vernacular architecture presents basic and simple solutions for the sustainable issues because it has significant environmentally features that respond to sustainability such as low-energy techniques to provide for human comfort, approaches that are integral to the form, orientation, and materials that are obtained from local resources. With the evidence that vernacular architecture has some of the remarkable features of sustainability, this study aims to examine Şirince vernacular settlement in the western of Turkey in order to explore inherited experiences and knowledge, and lessons learned from the past. Analysing environmentally-responsive features of vernacular architecture will provide significant insights and lessons for designers who are involved in development of future sustainable built environments.

Keywords: *Vernacular architecture, Sustainability, Sustainable considerations, Sustainable built environment, Environmental friendly approaches*

1 INTRODUCTION

Vernacular architecture reveals the combination of local climate conditions, locally available materials, simple construction techniques, living style, traditions and socioeconomic conditions of the region. According to Lawrence (2006), vernacular buildings are human constructs that are the results of relationships among ecological, economic, material, and social factors. Due to the fact that vernacular architecture has evolved through trial and error methods, vernacular buildings and site planning depend on substantially experience, surrounding conditions, and local materials such as adobe, stone and timber. Specifically, vernacular architecture is taken attention in terms of its continuity. Thus, it can be seen as the essence of sustainability with its inherent characteristics. Moreover, vernacular settlements are often considered as the predecessors of sustainable built environments.

In order to analyse existing vernacular architecture, it is important to gain a good understanding of what the sustainability issues can be in building design and construction. By realizing the depletion of energy resources, it has been focused on energy efficiency and conservation of natural resources.

Buildings account for at least 40% of energy use, and this using is rising dramatically. The built environment has a significant impact on the natural environment, human health, and economy. Sustainability in the field of architecture requires environmentally friendly approaches. Thus, sustainable building designing involves integrating environmental, social and economic objectives. Some important issues to consider include: Energy consumption during construction and use, energy efficiency measures, the use of renewable energy; environmental sustainability of building materials; indoor environmental quality; consumption of potable water, water efficiency and recycling measures; waste management and recycling facilities; access to public transport and cycling facilities; atmospheric emissions, waste water discharges and surface water run-off; land use, local ecology, visual impact, contextual fit and community relations.

It has been observed that there is a significant shift to new building design strategies taking into account sustainable considerations in the last twenty years. However, in most countries, sustainable buildings are still at a nascent phase of development. The construction industry has more needed knowledge, and industry professionals (in both the design and construction disciplines) continually seek for best solutions in practices in order to understand of how to apply sustainable considerations to buildings. The growing awareness of sustainable building's potential to positively impact environmental issues pushes knowledge to the forefront. In this respect, vernacular architecture presents simple solutions for the sustainable issues because it has significant environmentally features that respond to sustainability such as low-energy techniques to provide for human comfort, approaches that are integral to the form, orientation, and materials that are obtained from local resources. Hence, in recent years professionals have begun to rediscover vernacular architecture features due to the increasing challenges about providing sustainability in a built environment.

A review of existing literature on vernacular architecture indicates that vernacular buildings and correspondingly settlements have ecological implications for sustainable architecture today. A study conducted by Dayaratne (2000) on learning from tradition for an environmentally responsive architecture shows how vernacular architecture has been inherently sustainable. A research on climatically responsive indigenous buildings and settlements in two desert conditions of India conducted by Krishnan et al. (2001) reveals that there is a high thermal performance in these buildings. Naciri (2007) points out that vernacular architecture has some features that could inspire the designers and engineers interested in passive climate controls. Additionally, Kazimee (2008) underlines that "vernacular architecture is a learning method by which global challenges can be addressed, which are global warming, housing crises, and economic equality." Also, Ozkan (2006) and Sundarraja et al. (2009) emphasize that vernacular architecture as the earliest form of sustainable building, as it not only uses the most accessible materials, but also employs available technologies. According to Rakoto-Joseph et al. (2009), vernacular architecture presents a simple and efficient solution for buildings in order to struggle with the climate conditions and topographic constraints. Moreover, Zhai and Previtali (2010) state that considering the features of vernacular architecture as an approach to improving building energy performance can help enhance the performance.

Evidently, vernacular architecture represents inherent, unwritten information for understanding the value of experiences related to sustainability. Thus, vernacular buildings and correspondingly settlements can be accepted as a knowledge source for sustainable building design ideas. Therefore, lessons learned from vernacular architecture can help in designing of environmentally friendly built environments.

In the sustainability context, analysing environmentally-responsive features of vernacular architecture will provide significant insights and lessons for designers who are involved in the development of future sustainable built environments. Hence, in this study vernacular architecture is focused in order to explore inherited experiences and knowledge related to sustainable considerations, and lessons learned from the past. To that end, with the evidence that vernacular architecture has some of the remarkable features of sustainability, this study intends to examine a vernacular settlement in the western of Turkey.

2 RESEARCH METHODOLOGY

In this study, the case study method was conducted in order to illustrate sustainable features in an existing vernacular settlement. The use of the case study method provides a detailed examination and also a rich description. Therefore, for the case study Şirince vernacular settlement of western Turkey was selected because houses were more than 100 years old and still in use. Specifically, this case study was carried out for finding out the available sustainable considerations such as compatibility with topographic and climatic conditions, common building plans, materials and low-tech used and solar passive features in the vernacular buildings of Mediterranean climatic conditions of the region. To that end, Şirince vernacular architecture was analysed in terms of site planning, building form and orientation, construction materials and techniques, openings and shading in the context of sustainability. The pictures were taken in this place in order to illustrate its features and form of the present day. Findings were discussed in terms of sustainable considerations.

2.1 ŞİRİNCE VILLAGE: A TURKISH VERNACULAR SETTLEMENT IN PROVINCE OF İZMİR

Şirince (meaning pleasant in Turkish) is a small vernacular settlement in the Aegean region of Turkey, and one of the 8 villages of Selçuk District of İzmir Province (Figure 1). It is an inland, hillside village, and surrounded by agricultural lands. Şirince is located at the south and east sides of a valley approximately 375 m high from the sea level. There are hills on the south and east boundaries of the settlement. On the north side there is a plain, and on the west side there is a second valley. Also, there is a riverbed that runs south to north as a natural boundary that divides the settlement into two neighborhoods. Agricultural fields such as vineyards and fruit gardens are mostly located outside the settlement on the flat areas of the plain. The settlement is located in first degree earthquake zone of Turkey. Also, it has in a significant location in terms of tourism because of the fact that there are archaeological sites including Ephesos, Miletos, Priene, House of Holy Virgin Mary, and other tourist centres like Kuşadası and Selçuk and beaches like Pamucak Beach in its vicinity.

Figure 1. Overview of Şirince Village (Edited from Google Maps, 2012)

The history of Şirince is based on until 14th century. However, construction techniques of buildings reflect features of 19th century. After the discovery of the House of Holy Virgin Mary in 1891, Şirince was described as a Christian town that had a population of 4000 people (Uyar, 2004). In the early 20th century the population of Şirince was between 4000-7000 and the number of houses was between 1100-1800 (Beker, 2002) According to the 2010 census, today the population of the village is 534 (TUIK, 2010). The economy of the village depends on agriculture, especially on olive and grape cultivation, and recently has been supported by tourism.

The first conservation activity in the village is the registration of the two churches in 1978 by the decision of the Supreme Council for the Immovable Historic Assets and Monuments (Akdogan, 2007). In 1984, Şirince was accepted as a "Historic Site" and 88 traditional houses were registered as a cultural asset. In 2002, Turkish Ministry of Culture and Tourism began to conduct Conservation Plan studies for the conservation, promotion and transmission of the historic and cultural heritage to future generations. In 2006, this plan was approved by the İzmir Provincial Special

Administration. Today, the number of registered vernacular buildings is 125 (Akdogan, 2007). These buildings can be classified as follow:

- 2 Churches (St. John and St. Demetrious)
- 2 Fountains
- 1 Traditional olive oil factory
- 1 Furnace
- 1 Primary school (It is being used as a restaurant)
- 7 Stores
- 111 traditional houses: 70 of which are being used as residences, 5 of which are being used as cottages, 19 of which are being used as pensions, 17 of which were abandoned

Şirince village has significant values, the natural beauty of flora and fauna and includes the cultural remains of various communities which indicate their presence in the region from past to present. In this respect, the region is hosting an original vernacular settlement. A field survey in order to determine the current situations and functions of the registered Şirince historic buildings and site conducted by Akdogan (2007) reveals that there are the historical, architectural, aesthetic, and economic values of Şirince. These values include:

- Historical value: Şirince provides information about the past which is not available from any other sources. Historic houses reflect the living conditions and the construction techniques of 19th century. Also, it has a historical value because of the events related to population exchange.
- Architectural value: The houses are the representatives of the vernacular architecture of the region.
- Aesthetic value: The village has a well preserved vernacular pattern and natural landscape.
- Economic value: Historic buildings have economic value because commercial use of these buildings as mostly pensions and restaurants. This provides a significant revenue source for the owners.

Climatic data

İzmir province has a Mediterranean climate which is characterized by hot and dry summers; and mild to cool, wet winters. The average precipitation for İzmir is approximately 686 millimetres per year. However, 77% of that falls during November through March (Table 1). The rest of the precipitation falls during April through May and September through October. The rainfall is rarely seen during the months of June, July and August.

3 ANALYSIS OF BUILT ENVIRONMENT IN ŞİRİNCE VILLAGE

Şirince has a vernacular character with its unique architectural pattern. This study examines vernacular architectural features that found in Şirince Village in order to reveal it as a knowledge source for sustainable building solutions. In this respect, vernacular settlement and houses in Şirince Village are analysed in terms of site planning, building form and orientation, construction materials and techniques, openings and shading.

Table 1: Climate Data for İzmir Province (Turkish Meteorological Service, World Meteorological Organization, and BBC Weather)

Climate data for İzmir province													
Month	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Year**
Record high °C (°F)	22.4 (72.3)	23.8 (74.8)	30.5 (86.9)	32.2 (90.0)	37.5 (99.5)	41.3 (106.3)	42.6 (108.7)	43.0 (109.4)	40.1 (104.2)	36.0 (96.8)	29.0 (84.2)	25.2 (77.4)	43 (109.4)
Average high °C (°F)	12.6 (54.7)	13.4 (56.1)	16.5 (61.7)	20.9 (69.6)	26.1 (79.0)	31.0 (87.8)	33.3 (91.9)	32.8 (91.0)	29.1 (84.4)	24.0 (75.2)	18.2 (64.8)	13.9 (57.0)	22.65 (72.77)
Daily mean °C (°F)	8.9 (48.0)	9.4 (48.9)	11.8 (53.2)	15.9 (60.6)	20.9 (69.6)	25.8 (78.4)	28.1 (82.6)	27.6 (81.7)	23.7 (74.7)	18.8 (65.8)	13.7 (56.7)	10.3 (50.5)	17.91 (64.23)
Average low °C (°F)	5.9 (42.6)	6.2 (43.2)	8.0 (46.4)	11.5 (52.7)	15.6 (60.1)	20.2 (68.4)	22.9 (73.2)	22.7 (72.9)	18.9 (66.0)	14.8 (58.6)	10.4 (50.7)	7.5 (45.5)	13.72 (56.69)
Record low °C (°F)	−4 (25)	−5 (23)	−3.1 (26.4)	0.6 (33.1)	7.0 (44.6)	10.0 (50.0)	16.1 (61.0)	15.6 (60.1)	10.0 (50.0)	5.3 (41.5)	0.0 (32.0)	−2.7 (27.1)	−5 (23)
Rainfall mm (inches)	131.2 (5.165)	98.8 (3.89)	76.7 (3.02)	44.1 (1.736)	31.8 (1.252)	7.9 (0.311)	2.1 (0.083)	2.2 (0.087)	10.7 (0.421)	37.9 (1.492)	92.1 (3.626)	150.8 (5.937)	686.3 (27.02)
% humidity	68	63	62	58	55	48	42	47	53	60	68	70	57.8
Avg. rainy days	12.7	10.7	9.3	8.1	5.2	2.1	0.7	0.7	2.0	5.6	9.0	13.0	79.1
Mean monthly sunshine hours	133.3	141.3	195.3	219.0	294.5	342.0	375.1	353.4	300.0	226.3	159.0	124.0	2,863.2

3.1 Site planning

Şirince village was conveniently located on a sloping terrain, and reflects an example of the terraced pattern of vernacular architecture (Figure 2).

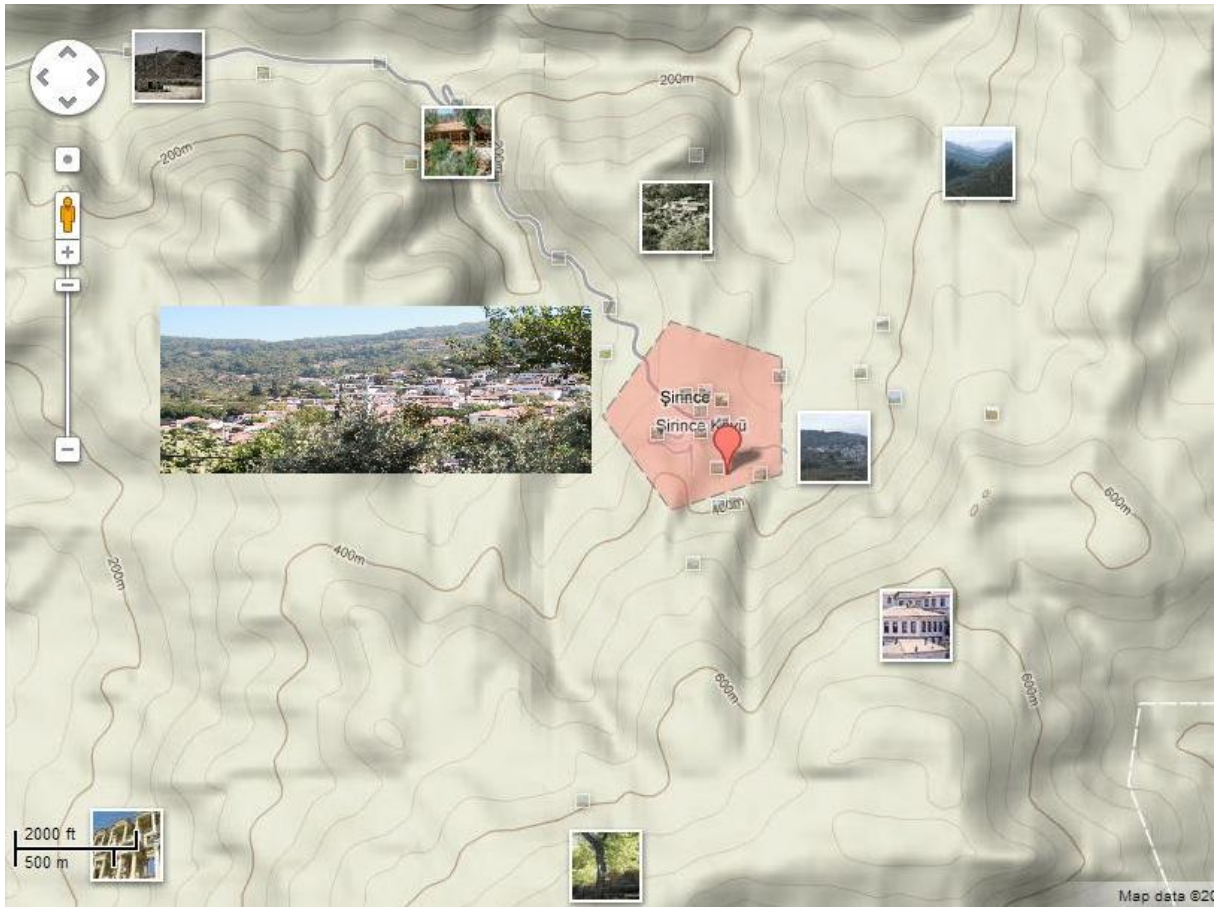

Figure 2: Location of Şirince Village (Edited from Google Maps, 2012)

There is one road in order to access to the village. This road makes a loop in the eastern village square. This also is the main vehicular axis within the village. The main pedestrian axis starts at the eastern village square, continues the western square which is used as a traditional commercial area (Figure 3) in the middle of the settlement and reaches to St. John the Baptist Church (Figure 4). Houses were mostly built around this western square. This built environment is surrounded by agricultural lands in the region.

Figure 3: Traditional Commercial Area in Şirince Village (Photograph by author, 2012)

Figure 4: St. John the Baptist Church (Photograph by author, 2012)

Topography consisting of steep slopes affects the location of the houses and the form of the streets in this settlement. The houses are located on the two sides of the valley (Figure 5). The streets are narrow, sloping, and sinuous shape due to topography (Figure 6), on the west slopes to north-south direction and on the south slopes to east-west direction. However, some streets are built with stairs and stepped slopes in order to reduce the pitch (Figure 7). Also, streets are made of rubble stone.

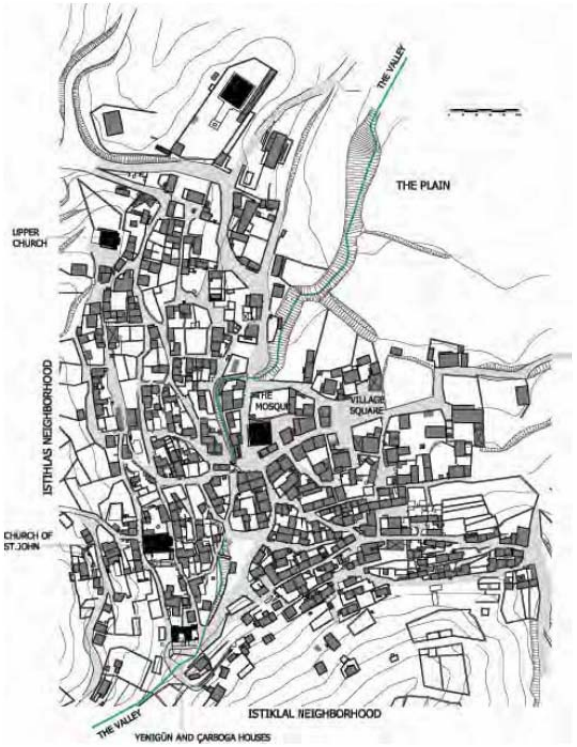

Figure 5. Site Plan of Şirince Village: The Houses are Located on the Two Sides of the Valley (Uyar, 2004).

Figure 6. A View of a Typical Narrow, Sloping, and Sinuous Street (Photograph by author, 2012)

Figure 7. The Street Made of Rubble Stone and Built with Stairs in order to Reduce the Pitch (Photograph by author, 2012)

3.2 Building form and orientation

Topography is dominant factor for the configuration of Şirince houses. The houses are placed parallel to topography in north-south orientation that is toward the valley. Şirince houses are built over the sloping topography as a detached house (Figure 8) or contiguous houses (Figure 9).

Figure 8: Detached House (Photograph by author, 2012)

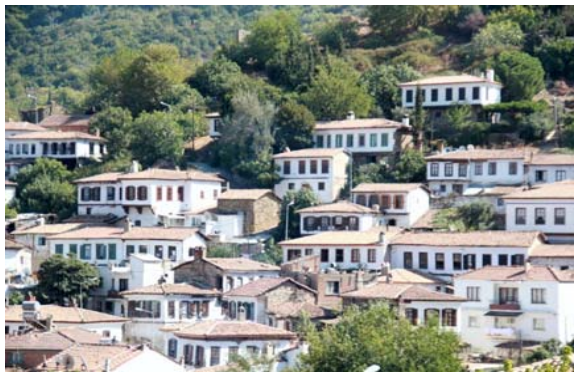

Figure 9: Contiguous Houses (Photograph by author, 2012)

One side of some houses is near the upstream slope or embedded and their other side looks to downstream slope. Thus, the front façades facing the view are two storeys, whereas the back façades are single storey (Figure 10). However, the houses are built respectful to each other. They are oriented without blocking each other view, sun and wind.

Figure 10: Different View of Façades due to Topography (Photograph by author, 2012)

These houses have mostly rectangular plan type, and are usually two-storied (Figure 11). One-storied and three-storied houses are quite few. On the ground floors show introvert features while on the upper floors are extrovert features. The entrances of the houses are generally on the ground floors. On the ground floors are mostly used for common areas like livestock and storage spaces. The living areas are all upper floors. Rooms have like living space, kitchen, and bedroom functions.

Figure 11: A View of Two-Storied Houses (Photograph by author, 2012)

Some of these houses have open spaces mostly like front garden are enclosed by walls which from the street (Figure 12). However, some of them are entered directly from the street (Figure 13). These gardens are mostly located between the street and the main façade of the house and the house is usually entered from these front gardens (Figure 14).

Figure 12: Entrance from the Garden Enclosed by a Wall which from the Street (Photograph by author, 2012)

Figure 13: Entrance Directly from the Street (Photograph by author, 2012)

Figure 14: A View of Front Garden (Photograph by author, 2012)

3.3 Construction materials and techniques

It is observed that stone and wood are used as main construction materials which are available locally in this settlement. Stone is mostly used to construct the walls especially on the ground floors (Figure 15). Furnace, fireplace and chimney systems are also made of stone. Using areas of wood in the vernacular houses of Şirince are similar throughout the region. Wood has been used in wall systems of upper floors as load-bearing stud, filler,

interior partition walls, on beams and veneering of floor, at all kinds of door and window furniture and all the roof elements in almost all houses. Lime which has a limited usage field in the houses is mostly used as plaster and mortar material.

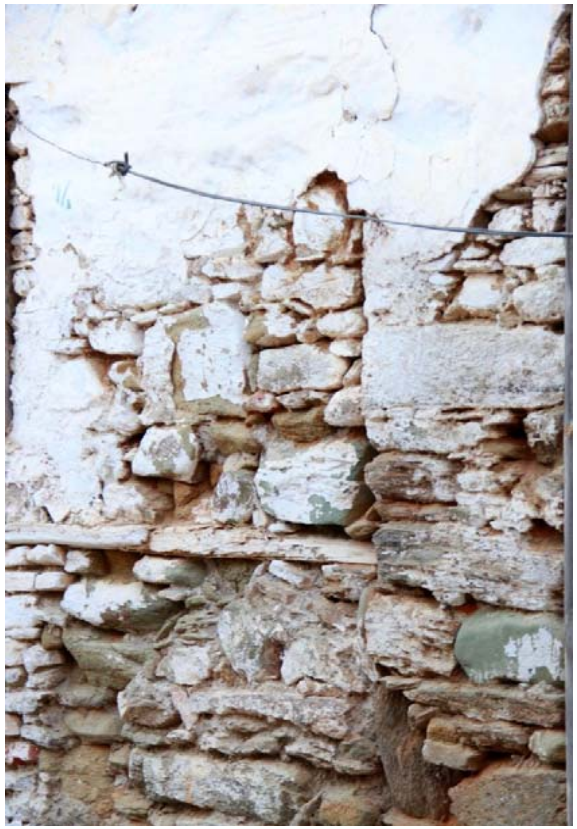

Figure 15. Rubble Stone Wall (Photograph by author, 2012)

Construction technique of Şirince houses is composed of masonry and timber frame. The ground floors of these houses are constructed in rubble stone masonry, and covered with lime plaster and white wash, and then continued with timber frame structure for the upper floors of the houses (Figure 16). Some of the houses have wooden orioles. The filling of this frame is consisted of mostly rubble stone. The interior walls are usually timber frame structure with lime plaster on wood lath.

Figure 16: Construction Technique: Rubble Stone Masonry on the Ground Floor and Timber Frame on the Upper Floor (Photograph by author, 2012)

The houses have pitched roofs and sloped roofs which are made of wood and covered with French tiles. They also have eave made of wood (Figure 17). The eave projects approximately 30 cm on the façades, and has a convex shaped. Underneath the eave is covered with wood lath or lime plaster.

a

b

Figure 17: Eaves Covered with Wood Lath (a) or Lime Plaster (b) (Photographs by author, 2012)

The garden walls aren't high and they are made of rubble stone with plaster or without plaster, and are covered organically with vegetation (Figure 18). Lime mortar is used as binding material in the stone walls.

Figure 18: The Garden Wall Covered with Vegetation (Photograph by author, 2012)

3.4 Openings and shading

The windows and doors are completely wooden structures and opened depending on the occupant's requirements. The most distinctive feature is rows of modular windows (Figure19). The proportions of windows are nearly 1/2. Thin pieces of wood-lath are nailed on window jamb and the glass pane is placed in between. In order to open the window, the panes are removed from the window and put aside. Typically, Şirince houses have small size windows and are built generally very close to each other. This provides a skillful adaptation to the local climatic conditions.

Figure 19. Modular and Wooden Windows (Photograph by author, 2012)

In these houses traditional external shutters are used (Figure 20). The shutters of windows are formed of two vertical timber planks attached to three horizontal planks. On two sides of the windows on wall surface there are metal elements that are twisted over the shutters to keep them open.

Figure 20. The Shutter Made of Wood (Photograph by author, 2012)

4 FINDINGS AND DISCUSSION

In this section, the findings obtained from the examination of Şirince vernacular architecture are briefly discussed in terms of sustainable considerations such as site planning, building form and orientation, construction materials and techniques, openings and shading.

It is quite interesting to note that Şirince vernacular settlement provides efficient solutions to the climatic and topographic constraints of the region. The site planning was discovered to be particularly comfortable in providing not only shade but also air circulation in the settlement. The streets are narrow and never rectilinear with parallel sides. Form of the streets contributes to the ecological regulation. Therefore, the streets stay shaded most of the day in the summer.

Şirince houses have minimum surface to volume ratio which maximizes the heat gain inside the rooms during daytime and minimizes the heat loss during nighttime. In addition, the north south orientation of main façades provides air ventilation that requires orientation to suit prevailing wind directions. This feature enhances natural ventilation by increasing air circulation through the opening in the room. North facing façades present an opportunity to provide views, whilst minimizing solar heat gains. This leads

to the highest intensity of solar radiation being on the east and west facing walls in summer and the south wall in winter. East and west façades serve as thermal mass buffers. Also, the houses are compact and correspondingly the windows are small in size. These features help to reduce heat loss from inside the house in winter. The rooms with minimum openings and wooden walls provide refuge from the cold conditions outside while conserving inner heat in winter. However, the orientation of the rooms towards the garden creates good cross natural ventilation during the warm weather. This therefore adds to the comfort within the house enhancing air circulation. Additionally the amount of sunlight, cold, and wind accessing the rooms is controlled using wooden shutters. This traditional external shutter is an effective shading device. Therefore, the use of these shading devices also helps regulate the climate inside house. Furthermore, the roofs of these houses are extended to act as an overhang to protect the walls of the house from rainfall.

The garden inside house is a common and characteristic form of Şirince vernacular architecture in Mediterranean climatic conditions. This serves as buffer zones both for climatic reasons and to support privacy. The main difficulty in this climatic zone is overheating with solar radiation. These gardens serve as a collector of cool air at night and a source of shade in the daytime. Climatic advantage of these gardens is the fact that they provide the ventilation and passive cooling. Additionally in these houses white paint is used to reflect back solar radiation.

In most of the houses, locally available materials like stone and wood are used. Since these materials are from the same climatic zone, they fit perfectly into the local environment. Use of locally available material has environmental advantages such as significant reduction in energy involved in material processing and transportation, low environmental impact in their production. The use of wood material improves the inside comfort conditions. The main advantage of using wood for construction is that it is hard, resistant to moisture and has poor thermal conductivity. The use of the timber frame structure also provides a lighter construction, ensuring better seismic response of the building during earthquake. The filling walls on the upper floors of these houses serve as great insulators and at the same time allow the absorbing and storing of heat and coolness. The back façades of some houses are in rubble stone masonry. They are meant to serve as extensive thermal masses.

5 CONCLUSION

In this study vernacular architecture was examined as a knowledge source for sustainable building solutions. The key features concerning sustainability in vernacular architecture were identified by analysing Şirince vernacular settlement and correspondingly houses in western Turkey.

The most important goals of sustainable building projects are adaptation to flexible and changing environmental conditions, long life, energy conservation, minimization of waste, low cost of maintenance, and providing humans with the best indoor air quality. In this respect, the result of this examination indicates that Şirince vernacular architecture have significant sustainable features due to the fact that it incorporates the use of local materials and indigenous building sources, incentive to promote the continuation of low-tech and environmentally friendly solutions, and energy-efficient design principles. For instance, most of the houses have some solar passive features such as enhanced air circulation, promoting natural ventilation, reducing heat gain and effective shading solutions. In addition, Şirince vernacular houses were built with the use of locally available limited resources to adapt themselves with the geo-climatic conditions of the terrain. Using locally available materials for construction of these houses decreases the building material processing and transportation costs. These houses have also provided energy efficiency and thermal comfort to the occupants of the settlement for most part of the year without using any artificial costly source of energy by using materials with less embodied and operational energy. Hence, Şirince houses are not only vernacular but also reflect the sustainable features of a built environment. As a conclusion, the study shows that vernacular settlements present a significant opportunity in order to discover experiences related to sustainability. Vvernacular architecture has inherent benefits with its environmentally friendly approaches. Hence, vernacular architecture must

be seen as a knowledge source that could inspire the designers and professionals interested in sustainability.

REFERENCES

Akdogan, K. N. (2007). Management plan of Sirince Village. http://www.hdm.lth.se/fileadmin/hdm/alumni/papers/CMHB_2007/Turkey__Kivilcim_Nese__Akdogan.pdf Accessed on 25th August 2012.

BBC Weather. http://www.bbc.co.uk/weather. Accessed on 10th August 2012.

Beker, O. (2002). Research report of Şirince Conservation Plan. Ankara, Turkey.

Dayaratne, R. (2000). Learning from tradition for an environmentally responsive architecture: A formal practice. Open House International. 25 (03), 10-15.

Lawrence, R. J. (2006). *Learning from the vernacular: Basic principles for sustaining human habitats*. In: Asquith, L. and Vellinga, M. (ed.). Vernacular architecture in the twenty-first century. Theory, education and practice. Milton Park, Abingdon: Taylor & Francis.

Kazimee, B. (2008). *Learning from vernacular architecture.* In: Broadbent, G. et.al. (ed.) Architecture: Harmonisation between Architecture and Nature. UK: WIT Press. pp. 3-13.

Krishnan, A., Baker, N., Yannas, S., and Szokolay, S. V. (2001). *Climate responsive architecture: A design handbook for energy efficient buildings.* New Delhi: Tata McGraw-Hill.

Naciri, N. (2007). Sustainable features of the Vernacular Architecture. http://www.solaripedia.com/files/488.pdf Accessed on 20th August 2012.

Ozkan, S. (2006). *Traditionalism and vernacular architecture*. In: Asquith, L. & Vellinga, M. (eds.). Vernacular architecture in the twenty-first century. Theory, education and practice. Milton Park, Abingdon: Taylor & Francis.

Rakoto-Joseph, O., Garde, F., David, M., Adelard, L., and Randriamanantany, Z. A. (2009). Development of climatic zones and passive solar design in Madagascar. Energy Conversion and Management 50 (4), 1004-1010.

Sundarraja, M., Radhakrishnan, S. and Priya, R. (2009). Understanding vernacular architecture as a tool for sustainability. *Proceedings of 10th National Conference on Technological Trends,* Trivandrum.

TUIK. (2010). Address Based Population Registration System. Turkish Statistical Institute. http://tuikapp.tuik.gov.tr/adnksdagitapp/adnks.zul Accessed on 15th August 2012.

Uyar, S. (2004). Restoration Project of Çarboğa and Yenigün Houses in Şirince, İzmir. Unpublished master dissertation, Middle East Technical University, 2001.

Turkish Meteorological Service, http://www.mgm.gov.tr/index.aspx#sfU Accessed on 10th August 2012.

World Meteorological Organization. http://www.wmo.int/pages/index_en.html Accessed on 10th August 2012.

Zhai, Z., and Previtali, J. M. (2010). Ancient vernacular architecture: Characteristics categorization and energy performance evaluation. Energy and Buildings 42, 357-365.