

# Evaluation of a School Building in Turkey According to the Basic Sustainable Design Criteria

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**Abstract.** In Turkey, as well as many other developing countries, the significance of sustainable education buildings has only recently become recognized and the issue of sustainability issue has not been sufficiently involved in laws and regulations. In this study, first of all architectural sustainability with basic design criteria has been explained. After that selected type primary school project in Turkey has been evaluated according to the sustainable design criteria. Type project of school buildings significantly limits the sustainability performance expected from buildings. It is clear that type projects shorten the planning time as they include a designing process that is independent of settlement and they are repeated in various places with different characteristics, indeed. On the other hand; abundance of disadvantages such as the overlook of the natural physical and structural properties of the location mostly restricts the sustainable design of the building. For sustainable buildings, several factors such as the environment, land, climate, insolation, direction etc. shall be taken into consideration at the beginning stage. Therefore; implementation of type projects can be deemed to be inappropriate for sustainability.

## 1. Introduction

The human being has been in interaction with nature and environment since its existence and they have changed each other during the process. While in ancient ages, this change could be identified as cultural or social change only, with the introduction of the concepts of industry and technology, the venues for a living have been forced to change, too. Thanks to the ever-advancing science, technology, automation and computer technologies, new occupational areas have emerged and the economy has grown fast in this parallel. Along with these; uncontrolled industrialization, the amount of waste, pollution and greenhouse gas on earth and in the atmosphere significantly increased [1]. These intense pressures almost ruined the biochemical cycles and the ecosystem, and consequently, nature has become unable to regenerate itself. The environment designed through the utilization of available resources to provide the individuals with a place to live aims to fulfill the biological, psychological, socio-cultural and economic needs of the individuals by meeting the conditions for comfort. In designing environments that are suitable for the conditions of comfort, this purpose shall be taken into consideration when taking location decisions based on the natural air conditioning, lighting, heating and ventilation systems and when taking planning and designing decisions based on the building and place. A primary principle to take into consideration during the designing process of a structure is that; the structure shall meet the physical, social, psychological and economic needs of the people while being in unity with the natural environment conditions [2]. In order to ensure unity with the environments, designers shall prioritize the preservation of natural resources, environmental impact, and utilization of reproducible materials. Natural resources, the sun, materials, water and climatic data shall be used in a most efficient way; re-utilization and recycling processes shall be considered.



Architectural designs shall be sensitive to the environment and shall be based on the minimization of the consumption of resources and maximization of the use of natural power resources [3]. Education buildings, which are among the elements forming the structured environment, are important both for the society and for the individuals. Individuals form the basis of their life within the framework of the knowledge they have acquired in these buildings. Therefore; education buildings are more significant for children than other buildings, to raise awareness about, to implement, perceive, live and experience sustainability. On the other hand, it is also known that, millions of students on earth receive education in buildings that are insufficient in terms of air conditioning, heating, lighting and acoustic and which have negative impact on the stimulation of the exploring and creativity features of the students, which are required for the learning process, indeed [4].

In order to ensure sustainable life standards on earth for the future generations, provision of efficient education is one of the primary issues to be focused on, as well as the assessment and control of environmental impact. Particularly due to the ever increasing young population in Turkey, the design of education buildings shall consider the environmental sensitivity as an extension of education and education buildings shall be designed in parallel with the sustainability criteria.

Today, most of the total energy consumption is belongs to the construction industry. It is possible to minimize the impact of buildings by making use of technology, materials and current methods without the need to make a further research. School building industry itself is a big industry. Dealing with sustainability practices at schools in an integrated manner would lead to significant improvements in energy and resource consumption. In this sense also, it is important to determine sustainability criteria for school buildings and to put these into practice. In many countries like Turkey, standard type of school buildings provided with the state budget is built ignoring the climatic conditions and environmental factors. The significance of sustainable education buildings has only recently been recognized in Turkey, and the issue has not been sufficiently involved in laws and regulations, yet this research aims to make literature reviews on sustainability, sustainable architecture, and sustainable design and to determine the basic criteria regarding the designing of a sustainable education building. From this motivation, in this study, selected type primary school project has been evaluated according to the sustainable design criteria.

## **2. Sustainability and architectural sustainability**

With an ecological point of view, Foster [5] defines “sustainability” in the simplest and clearest way as; “less is more”, which means the ability to manage the most by using the resources the least. The concept of sustainability developed in 1972, through the discussions within the framework of the “eco-development” concept included in the World Environment Conference made in Stockholm with The Club of Rome. Though sustainability is studied on several platforms in many occupational fields, it takes attention that researchers have developed a common perspective when defining the components that form sustainability, based on the ecologic, economic and social aspects of the concepts. For example; some researchers [6], [7] define three categories to classify the data that are influential on the emergence and change of the sustainability concept.

- Ecologic Data; Climatic changes, Difference mitigation, Ecologic factors (environmental sensitivity), Food chain and transformation, Development of the concepts of resource and waste, Energy consumption
- Economic Data; Development of the concepts of agriculture and transportation, Industrial development
- Social-cultural Data; Individual and public consciousness-raising (human rights), Investigation of population, intensity and carriage capacity relationships, Historical awareness and development

As the building industry has a significant impact on the global environment today, it must be a priority to recover the environmental impact created by all negative activities about a building. As well as other fields, the current situation shall be analyzed first and discussions shall be made concerning the measures to be taken in the architecture field. Definitions intended for enabling and sustaining healthy living conditions on earth for future generations shall be readdressed in parallel with the conditions

that change in time. Sustainable architecture is the main body covering previous architectural approaches and is a comprehensive, strategic and planned way of the building supported by global environmental problems and development problems. Thus; architectural practice is projected to be environment-friendly not only with its morphological properties but also with the contribution it makes to the social, cultural and economic infrastructure. Sustainable architecture is a controversial issue that is often dealt with in international research. Utilization of a rich terminology in the classification of buildings indicates the broadness of the issue and complication of concepts, even the presence of a chaos. Several terms such as environmental design, green architecture, ecologic architecture, environment-friendly architecture, architecture sensitive to the environment, smart architecture, energy-efficient architecture, energy-conscious architecture, climatic architecture address to complicated, conflicting and competing practices [8]. Sustainable design can integrate the life cycles of building systems with the ecologic systems in the biosphere. Components of a building and energy systems shall work in harmony with ecologic systems from resource to the smallest equipment in the building. A successful ecologic building shall have minimum destructive and maximum positive impact on natural systems.

### **3. Basic criteria in the design of sustainable education building**

Sustainable education building can describe as affect the ecosystem and near-environment, have low construction and maintenance cost, have recycling construction materials, having high social and ecological efficiency. According to Commercial International Bank (CIB) [9] and Sakınç [10], main targets of sustainable buildings are reducing using sources, preserving ecological and nature environment, getting human health and comfort top level, taking into account the socio-economic, cultural and political realities of the place. High goals for sustainable buildings can only be achieved through detailed analyses, cost and performance calculations and through dynamic and integrated design methods requiring returns and changes. According to Sakınç [10], the basic steps used in the design of a sustainable building are 1) Basic goals are identified 2) Basic decisions are taken 3) Preliminary design is made 4) Design 5) Enhanced design

Sustainable design of education buildings and integration of sustainable practices would have a high positive impact on energy and resource consumption. It is particularly important to offer social sustainability to students as a philosophy of life. To achieve this, buildings occupied by students shall be carefully designed in terms of sustainability criteria.

The sustainable design shall be discussed in a way that will ensure a healthy cycle in nature-human/society as a whole. In sustainable design; physical criteria such as climatic properties, positioning of buildings, building design, building form, spatial organization, material selection, sanitation system hardware and suitable plant cover are important. Turkish Green Building Council is an institution that contributes to the development of the building industry in parallel with sustainable principles in terms of green building and sustainability issues. There are several green building certification systems in the world intended for sustainable building surveillance. Building Research Establishment Environmental Assessment Method (BREEAM), Leadership in Energy and Environmental Design (LEED) and Comprehensive Assessment System for Built Environment Efficiency (CASBEE) are among the most important of these. The general objective of these systems is to reduce the environmental impact of building and building activities through life cycle approach. Models that are initially developed in parallel with the conditions of the country they have originated from are also in developing countries in time, either directly or after modification. Certification systems were assessed in terms of sustainable lands, water conservation, internal air quality, selection of appropriate material and building components, efficiency in water conservation, energy and atmosphere. Sustainable buildings can be detailed in terms of ecologic, economic, social and cultural sustainability in a way that will involve the common issues included by certification systems.

### **4. Basic criteria in the design of sustainable education building: sample type project in Turkey**

The school building conducted in the scope of study selected from Konya province of Turkey. The school building constructed in 2014 by government as a type project with 24 classrooms. The

population of the school is 535 with 6-11 aged children. The buildings locations and general façade view is given in Figure 1.



**Figure 1.** The buildings locations and general façade view

#### 4.1. Design criteria about ecologic sustainability

Ecologic sustainability includes the economic use of resources, preference of renewable energy sources and preservation of ecosystems. Economic sustainability is divided into two groups as investment and utilization cost. It is significant that building processes, building components, and materials are cost efficient, highly resistant and reusable. By renewing and reusing buildings, “long-term efficiency of resource” is ensured. Low utilization costs are achieved through efficient energy consumption of the building and through simple operation and maintenance. Social and cultural aspects of sustainability are the preservation of health and comfort as well as the values which is the main goal of preservation projects. As ecologic sustainability includes the economic use of resources, preference of renewable energy sources and preservation of ecosystems, selection of location, water conservation, energy and atmosphere, transportation, natural lighting, natural air conditioning and the criteria of distance between buildings are discussed under this heading.

**4.1.1. Selection of location.** Education buildings shall be assessed in terms of topography, land form, underground and above ground riches, settlement pattern, climatic regions and protection from or benefiting from the sun. In this sense, selection of location is the primary and preliminary parameter for sustainability. According to Kayihan (2016) [11], the main goal in the selection of a sustainable land is the protection of the users of the education building from external pollutants and preferring central locations with complete infrastructure, to which, users can safely access without transportation problem and which have minimum negative impact on the natural habitat and vegetation. The selected school building is located east-west. Daylight in the south should be under control. The classes in the north can experience warming problems because they cannot benefit from daylight. As seen in the school building site plan, the garden has settled on the ground as it will be in front. The building is in semiarid climate zone in Turkey.

**4.1.2. Water conservation.** Water becomes more valuable day by day. It is significant to keep water consumption at an optimal level in education buildings and to reuse the consumed water after purification. Controlling rainwater is also vital for the safety of the school area and ecology as well as water resources on earth and natural habitats. The main goal for water conservation is to protect undesirable excessive water from impermeable layers and to prevent pollution caused by rainwater accumulation. When rainwater is collected and used, low energy consuming installations and tools are used in buildings, water consumption, which is one of the main problems in certain regions, is reduced and the building becomes more ecologic. In this sense, covering materials to be used in the landscape shall be selected from permeable materials that would allow rainwater to reach the ground water. There is no controlling for rainwater in the school.

**4.1.3 Energy and atmosphere.** A general feature of a sustainable education building is that it will enable the use of renewable energy resources instead of exhaustible resources. In parallel with this, the following methods shall be primarily preferred: utilization of wind and solar energy, obtaining solar energy through active solar system, obtaining electric energy through photoelectric transformation, obtaining solar energy through passive solar systems, utilization of Trombe wall, water wall, roof pool systems, metal solar wall systems, controlled double glass facade system, utilization of isolated profit systems in solar energy to create places (greenhouses, solar chambers) for heat accumulation and

storage, utilization of separate profit systems for solar energy and water heater collectors etc. Besides these methods, which enable direct acquisition of energy, indirect benefit systems shall be considered. For example Lakot [12], it involves a glass surface and a behind that surface, a thermal mass suitable for heat storage, such as concrete, solid brick, stone or mud brick, with a selective or black-dyed surface for maximum absorption of heat. As the sunlight is absorbed by the surface of the thermal mass and is transformed into heat, it is delivered to the surface of the thermal mass through transmission, and then to the interior through transportation and radiation. These systems are named as; Trombe wall, water wall, roof pool systems, metal solar wall system and controlled double-glass facades. The solar beams coming in at different times. For the evaluation of the day when the school building was received, the sunsets were viewed during the year, at 21:00 on 21 March, 21 June, 23 September and 21 December. The fact that the school building receives direct sunlight all year round reveals some problems in the use of classrooms. In addition, when the buildings around the school were examined, it was found that there was no high building and therefore the heat of the school and the heat to be taken from the sun are not interrupted. On the other hand, when we examine the illumination of the structure, it is observed that the sun rays thought to be used are not sufficient along the long corridors of the plan typology and even daytime they have to be supported with artificial light sources. This is only provided by the windows in the classrooms. From the standpoint of ecological sustainability components, it is seen that natural enlightenment is inadequate in general.

**4.1.4. Transportation** In sustainable school education buildings, transportation lines shall be determined, alternative vehicle transportation, roads, and car parks shall be considered, simple and safe mass transportation options shall be prioritized, car park areas shall be minimized, the number of pavements between residences and school shall be increased, roads shall be sufficiently illuminated to ensure safety of the users, alternative transportation (bike etc.) or pavements shall be projected and bike park areas shall be considered. Furthermore; it is necessary to design windows to enable the observation of areas where mass transportation vehicles wait, drop-off and pick-up, to provide sufficient illumination, to install security cameras and to minimize the amount of hidden areas that could facilitate potential crimes. In the selected school building, alternative vehicle transportation, roads, and car parks were considered.

**4.1.5. Natural lighting and natural air conditioning.** Sunlight is one of the most significant factors that play role in the formation of interior environment conditions. The contribution of sunlight to energy efficiency shall be clearly indicated for the content of sustainability concept and for smart use of energy in buildings. It is also necessary to develop efficient methods intended for the assessment of the contribution of sunlight to the building in terms of energy. Concerning natural lighting and air conditioning criteria for sustainable preschool buildings, the direction should be taken into consideration when sizing window spaces manually-controlled shading elements should be used in front of the windows. Artificial lighting should be supporting the natural lighting as much as possible. Top windows and lights should be used in design and venues should be painted in light colors. With the design of window spaces and directions of the openings and the use of controlled air conditioning system, the quality of the interiors should be improved. The control system should be able to switch off the air conditioning system when the doors and windows are opened. Users should be informed about the use of electric control systems and the amounts of energy consumption. In the school building, artificial lighting is used throughout the school corridor throughout the day, while there is no problem with lighting in the classrooms (Figure 2 and Figure 3).

Heating in the school is provided by natural gas. There is no heating problem. However, different methods have not been developed to reduce energy consumption. The school does not have solar energy. Solar energy will contribute greatly in order to benefit from the warming of the school and hot water.





**Figure 2.** General view of classrooms and corridor

The school roof is quite suitable for the installation of solar panels. Insulation material used in the school is Expanded Polystyrene (EPS) which is an oil derivative material. Insulation is beneficial in terms of heating but it is a health hazardous material. There is no cooling system in the school. In the summer months, windows are opened and cooling is done. This causes noise to be affected during the course. In addition, dirty weather and the entrance of various classes into the classroom can disturb the students.

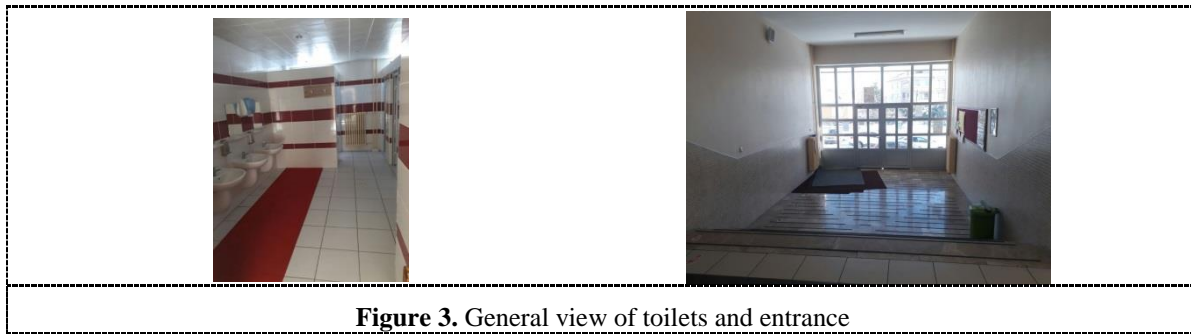
#### 4.2. Design Criteria about Economic Sustainability

According to Cole [13], economic sustainability is divided into two groups as investment and utilization cost. It is significant that building processes, building components, and materials are cost efficient, highly resistant and reusable. By renewing and reusing buildings, “long-term efficiency of resource” is ensured. Low utilization costs are achieved through efficient energy consumption of the building and through simple operation and maintenance. Building form, material selection, venue organization, building the shell and building positioning criteria are discussed under economic sustainability heading.

4.2.1. *Building Form.* A form of the building is one of the design criteria that have an impact on heating and air conditioning energy preservation. Building form can be defined through building related geometric variables such as the building shape (ratio of the building length to the building depth as stated in the plan), building height, roof type, inclination, the inclination of the facade surface. Ratio of the size of the building shell surface - which limits the venues to protect them from external factors- to building area, plays a significant role in energy loss and gain issues significant criteria that should be kept in mind when designing education buildings as sustainable buildings are the following; the width/length of the building should be designed by taking climatic data into consideration, minimization of building's external surface area, selection of optimal building forms by taking climatic data into consideration, determination of the height of floors in a way that would benefit most from natural lighting and designing of the waves of buildings for shading purpose.

4.2.2. *Selection of appropriate materials and building components.* In ecologic architecture, selection of materials is important for the sustainability of buildings. Selection of natural materials that would not harm the nature can come into minds for the first stage. Sustainable education buildings require the utilization of resistant materials, renewable and recyclable materials. Furthermore; utilization of energy efficient materials, from the acquisition of raw materials to their destruction in nature would be useful. It should also be kept in mind that, the basic ecologic design involves the critical selection of natural and environment friendly materials. The materials used throughout the school are generally the most commonly used materials today. But sustainable materials have not been selected. The rate of green space at the school garden is very low. There is a large hard floor in the garden. Garden floor material asphalt. This is not a suitable material for children. Asphalt material is dangerous for children because it is hard and slippery. In cold and rainy weather it is all caused by ice on the uneven floor.

4.2.3. *Spatial organization.* Spatial organization is the combination of user requirements and preferences and aesthetic decisions. Each of these components provides significant input concerning the energy performance and the environmental impact of the building. In this sense, the use of outdoor, semi-outdoor and indoor areas, positioning of these buildings, heat loss and gain on internal and external surfaces limiting the borders of the place determine the impact of the spatial organization on energy use.



**Figure 3.** General view of toilets and entrance

For a spatial organization in education buildings, gallery systems should be used as much as possible, it should be determined how much heat the places need and for which purposes such places will be used. In parallel with these, places that are desired to be continuously kept warm should be surrounded with places that are temporarily heated and the system should be embraced with a vertical and horizontal buffer zone. For interior comfort, it is important to use mobile materials such as exchangeable mobile panels to ensure a flexible interior design, to select an appropriate positioning to ensure the best insolation and to design appropriately positioned pass ways ( such as a greenhouse, glasshouse etc.). Enabling the use of places together with the surrounding community and selection of modular designs that could easily adjust to future needs are particularly important for social sustainability.

**4.2.4. Building shell.** Building shell is the component separating the interior building environment from the exterior building environment, which consists of all horizontal, vertical and inclined building components and it is the most significant variable for the energy conservation and the provision of climatic comfort. One of the criteria that should be kept in mind when designing the shell of education buildings is that, on facades which can make the best use of natural lighting, wide windows should be preferred and on facades exposed to dominant wind, the fewer amount of windows should be preferred. If possible, the use of natural green facades and roof, transparent insulation, roof and wall insulations should be at optimal level. Aesthetic needs, impact on the life cycle of the building and maintenance-repair needs should also be considered in selections.

#### *4.3. Design criteria about social and cultural sustainability*

Redclift [14] discusses sustainability within the framework of the continuity of the relations between individuals and social institutions regulating the natural, economic and politic contexts. In the most general meaning, social and cultural sustainability means; “preservation and development of social conditions that would help the fulfillment of human needs and environmental sustainability to ensure that natural resources are used efficiently by current and future generations”. According to CIB [9] and Sakinç [10], one of the basic goals of sustainable buildings is the preservation of the socio-economic, cultural and political requirements of the place. Basic principles of this goal are; understanding of the social and economic realities of the society, preservation of social and cultural diversities, understanding the social needs and demands, ensuring active participation of societies to the creation of their own living spaces. Among the socio-cultural sustainability components in sustainable education buildings are; design of building in harmony with its environment, the presence of symbols around the building, recovering the building from a ruined look, prevention of visual pollution, preservation of culture and heritage, improvement of life standards. As within the scope of sustainability it is required to raise the consciousness of people regarding the preservation of natural resources and handing those down the next generations, the issue should start with the children in education buildings [15].

## **5. Conclusion**

In order to be able to hand down a healthier environment to future generations, environmental consciousness of the people shall be raised first. Consciousness can be raised by educating school-age children with this sensitivity. When children grow up with ecologic consciousness starting from the school-age, they will be more sensitive to environmental problems in the future. When children

practice and experience the theoretical information they have gained, such information becomes permanent. An education building that is designed in parallel with sustainability criteria must be sufficient in all subheadings like land selection, utilization of natural resources, generation of energy through renewable methods, optimization of water consumption, recycling control, renewal, waste control, building maintenance, and repair. Sustainable education building design shall necessarily include certain parameters such as energy control and efficiency, the sufficiency of interior quality, user comfort and sensitivity of the building to the exterior environment. In Turkey, as well as many other developing countries, the significance of sustainable education buildings has only recently become recognized and the issue has not been sufficiently involved in laws and regulations, yet. A single type of school buildings significantly limits the sustainability performance expected from buildings. Standard type projects shorten the planning time as they include a designing process that is independent of settlement and they are repeated in various places with different characteristics, indeed. On the other hand; abundance of disadvantages such as the overlook of the natural physical and structural properties of the location mostly restricts the sustainable design of the building. For sustainable buildings, several factors such as the environment, land, climate, insolation, direction etc. shall be taken into consideration at the beginning stage. Therefore; implementation of standard type projects can be deemed to be inappropriate for sustainability. In a world, where the resources are rapidly being consumed, the sensitivity shown by developed countries to sustainable architecture shall be shown by developing countries, too. In order to hand down a healthier world to future generations, sustainable building techniques shall be included among the basic design criteria.

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