BİLDİRİ

EVALUATION OF LEED ‘WATER EFFICIENCY’ CASE STUDY: DİYARBAKIR, TURKEY

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Evaluation of LEED “Water Efficiency” case study: Diyarbakır Turkey

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ABSTRACT
Based on many scientific critics about the discrepancies between the aim with existing situation of assessment and certification systems oriented from environment friendly building approach, a trial of LEED on three houses of Diyarbakır settlement has been conducted, limited with water efficiency category. Although Diyarbakır houses, built approximately 300 years ago, have been proven to bear successful design strategies that address positive environmental effects, the evaluation results show that, houses cannot obtain any points under this category and have a very low outcome in total. It is believed and suggested that, with a more holistic approach based on interactions between the building and its environments, the assessment tools can be improved into a more integrative and balanced system towards beyond of green concept.

KEYWORDS
LEED, traditional buildings, regenerative design, Diyarbakır houses, life cycle assessment, environment friendly design, water efficiency, evaluation methods

INTRODUCTION
Environment is described as an ambience, which surrounds an entity and has an interactive and mutually influencing relationship with it [1]. Different from the other living entities, humans, forging their endeavours within the dominant worldview or prevailing paradigms, can affect the environment negatively [2] with their activities – especially by generating, using and disposing built environments. Substantially non-renewable resources are being depleted and environmental degradation gains speed.

Eco-efficiency, which aims to produce more with lesser resources [3], has developed some strategies such as environmental management systems or life cycle assessment methods [4], and this approach has been projected on the built environment as “environment-friendly” or “green” buildings [5]. Environment-friendly built environment concept basically aims the

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minimum consumption of resources (energy, product, water), minimum production of pollution (pollutants, waste, etc.) and minimum negative impact on health of humans and environment [6, 7]. Many scientific researches [7, 8, 9, 10, 11] point out that, with environment-friendly built environment, it is intended to do less harm, mainly to decrease the degradation on nature.

Along other negative impacts caused by humans, effects of built environment on nature prevent perpetuation of natural ecosystems for the future generations. Rees [12] discusses that negative impacts – even reduced – on ecosystems eventually lead to depletion of nature. Similarly, du Plessis [5] remarks that an evolutionary “dead-end” is being encountered through eco-efficiency as a result of intersection between its methods and natural boundaries of the world. All acknowledged statements point out a need for a shift, a transformation in approaches and regenerative paradigm, based on co-equal partnership [13], mutual beneficiary [14] and intention of perpetuation of nature [15], has been projected on built environment as regenerative design approach. Regenerative design presumes the built environment as a new and organized ecosystem; sees the design area as a part of bigger systems of natural and social environment, simultaneously including smaller environments and intends to benefit from and be useful to all these systems [16].

Many assessment methods are mainly built on inspecting the design and construction according to some specific energy consumption, waste and pollution production and performance objectives. These voluntarily implemented methods have been wide-spread since the 2000s. Although the popularization of these methods may seem like a positive development, this progress has been criticized due to reasons such as: the extensive effects of institutional priorities [17] and political impacts of the countries in which they have been formed rather than environmental concerns [5]; causing practical difficulties in other countries; and more importantly due to focusing on individual building performance by solely examining some properties about building products, energy efficiency and user comfort. Also the assessment criteria of these methods are being used as steps of a design strategy dominating the design phase single handedly and many participants have been implementing these methods to increase their market share and reliability in the construction industry.

It can be observed that many historical, yet still being used settlements, established centuries ago and produced anonymously by accurate public experience, can be acknowledged as successful examples according to principles of regenerative design through their environmental interactions between different local scales with positive production, usage and after-use practices in terms of regenerative thinking. It is reasonable to think that local builders, who know all characteristics of the region such as climate, social structure, local materials, water cycle, etc. have perfected this practice over centuries by trial and error. In many scientific researches, traditional buildings of Kayseri [18] and old Diyarbakır [19, 20] in Turkey; Yezd Settlement in Iran [21]; Najd, Hejaz, El-Ashaa and Asir regions in Saudi Arabia [22] comprise compatible examples with all environmental factors of the region. However, it can be observed that, these design practices and logical local solutions are overseen in contemporary architectural design processes or cannot find their suitable counterparts among the current certification methods. This problem results in the failure of many design approaches to take regional features into account due to the attempt of obtaining high scores and their failure to draw accurate environmental relations. In some scientific researches (i.e. [23]), this problem is addressed by re-evaluating certified buildings in terms of user comfort. Therefore, reconsidering popular assessment methods and eco-efficiency approach according to the design decisions through all stages of built environment, the effects of these decisions
on the relationship between building and its environments and determining their positive and negative aspects may improve these methods towards regenerative approach.

The main aim of this research is to evaluate vernacular buildings which have been proven to have successful environmental relationships by using a proper assessment method. It is hypothesized that, in spite of being produced centuries ago, based on their successful design decisions; the vernacular buildings may earn very high ratings.

Within this context, a trial of contemporary building assessment and certification systems on traditional buildings was conducted under the research project “An Examination of Traditional Buildings in terms of Life-Cycle: the LEED Assessment of the Diyarbakır Houses”\(^1\). Under this study;

- houses of old Diyarbakır Settlement, which were chosen due to the variety of their successful design strategies addressing positive climatic, physical and cultural effects [24, 25, 26], were evaluated as traditional buildings and
- the LEED certification system, which has been the origin of many similar tools, is used. Due to the lack of a system related to traditional buildings, LEED 2009 v.3 LEED for Homes is preferred. Owing to the fact that, this version of LEED has been used as a base for creating a Turkish environmental impact assessment tool; the LEED 2013 v.4 for Homes Design and Construction is kept out of scope.

This paper limits the LEED rating of Diyarbakır Houses to an assessment with respect to water efficiency and examination of other LEED categories are kept out to be handled under further researches. In this study, firstly, houses of old Diyarbakır Settlement and their properties about water usage are examined. For the assessment, three house types are chosen and assessment criteria about water efficiency are applied. Findings and results are used to evaluate the environmental aspects of the life cycle assessment and certification systems to procreate some recommendations for the improvement of these methods towards questioning environmental relations in a more integrative and holistic way through the regional aspects.

**HOUSES OF OLD DIYARBAKIR AND WATER USAGE**

With its history of hundreds of years, old Diyarbakır Settlement is situated in southeast Anatolia (38° 51’ N, 40° 21’E) (Fig. 1), on the east side of a basalt plateau with a slope of 7 % from north to south [27], approximately 650 m high from sea level and 100 m high from Tigris River [28]. The settlement is surrounded by nearly 5 km long, 8-12 m high, 3-5 m thick [29] city walls made of black basalt stones which have mostly been preserved since A.D. 375 [30]. In the vicinity of the settlement, there are mainly herbaceous plants; the steep slopes between the settlement and Tigris River hold very productive Hevsel Gardens, containing fruit trees and vegetable farms used by the local community for centuries (Fig. 2).

A harsh continental and subtropical plateau climate is dominant around old Diyarbakır Settlement. The summer season is very hot and mostly dry; winter period is rather warm compared to its neighbours; the average daily sunshine duration is 7.8 hours [29]. Hot period (approx. 8 months) is longer than the cold period (approx. 4 months). Around the settlement, the air is rather dry, precipitation mostly seen in winter and spring.

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\(^1\) This research project (Geleneksel Yapıların Yaşam Döngüsu Açısından İrdelenmesi: Diyarbakır Evlerinin LEED Değerlendirilmesi, No: 2012-03-01-KAP03) was carried out between 2012 – 2015 and supported by the Scientific Research Projects Coordinatorship of Yıldız Technical University in Istanbul, Turkey.
Because of the climate and city wall’s restriction [19, 20], the settlement was founded with low-rise, attached buildings which can be accessed through four main streets and narrow, shadowy, sinuous alleys forming an organic pattern.

Due to different factors such as climate [19], topography [26], plot sizes [30], social properties of local community [20], houses of Diyarbakır Settlement are mostly inward-looking, closely clustered and adjacent to each other. Nearly all houses have an open courtyard, one or two storey blocks surrounding this courtyard, positioned perpendicularly to each other. In the blocks, semi open eyvan (recess) and closed rooms are the other spaces that can all be accessed through the courtyard. Eyvan is a living space open on one side and connects to the courtyard. The blocks are mostly oriented to north or south [25] and households use the north oriented, mostly two storey block, which contains pantry, eyvan and rooms for family members during the hot period; whereas south oriented one storey block, which contains rooms, an anteroom and a kitchen niche, during the cold period. The east or west blocks in some houses are used during spring or autumn time. In Table 1 different house types according to the position of the blocks can be seen.

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2This figure was taken from Google Maps, 2015.
3This figure was adopted from Google Earth, 2013.
Because of adjacent planning, two storey summer block of a house stands next to one storey winter block of the neighbour.

**Table 1. Plan types of old Diyarbakır Houses**

<table>
<thead>
<tr>
<th>Plan Type</th>
<th>Exterior Court</th>
<th>Interior Court</th>
</tr>
</thead>
<tbody>
<tr>
<td>One-sided type</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I type</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Two-sided type</td>
<td></td>
<td></td>
</tr>
<tr>
<td>L type</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Three-sided (U) type</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Irregular type</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Courtyards, mostly in a square or rectangular plan, are the main living space [30] of the houses through the hot period [19, 24]. For providing privacy, courtyards are separated from the alleys and neighbour buildings by high, voidless walls and blocks. Floors of the courtyard and eyvan are covered with porous basalt stone [19]. In the courtyard, most of the houses have a pool (sizes changing between 1.00 x 1.80 – 3.00 x 5.00 m, depth of approx. 0.70 m) [30], a water well and fruit trees [26]. In some houses, water channels are carved out on the basalt flooring in which water can circulate from the pool through open and semi-open spaces [30]. The kitchen is mostly a niche opening to the courtyard and used only for cooking. WCs are mostly positioned nearby the entrance door, due to advantage of being close to the well organized sewer system of the settlement which is under the alleys and opens up to the Tigris River through Hevsel Gardens. Most of the houses do not have a bathroom; citizens use many hamams (public bathrooms) of the settlement in a regular base for bathing. Also, some houses have a special cool room called serdap in local language which has a floor at the same [20] or a lower [30] altitude than the courtyard and has a pool, situated mostly in the north facing block and covered with porous basalt as well. In Table 2, examples of a courtyard, an eyvan, water channels, a kitchen niche, a WC and a serdap can be seen.

Water is gathered from the water well or city fountains for cooking and washing activities and carried with buckets. Dishes and clothes are washed in courtyard and residents use the left water for cleaning the courtyard and other spaces. Due to hot arid climate, the required humidity is met by water in pools and channels. During hot summer days, residents spread water on the courtyard, eyvan and serdap floors. Especially, evaporation of this water in the pores supplies coolness. It is stated that, the very same method is being used in middle region of Saudi Arabia [22], where the climate and mass forms of old dwellings are very similar to Diyarbakır.

In the study, three houses are chosen, a single sided (House A), I type (House B) and irregular type (House C), due to reasons such as exemplifying the richest, well conserved and accessible samples in terms of variety and spaces (Table 3). House A is encircled by adjacent neighbour buildings in north, west and south and the courtyard of the house opens up to Bayrampaşa Alley in the east. A pool and a mulberry tree can be seen in the courtyard which faces the two storey block situated on the south part of the plot. This block contains an eyvan, four rooms, a kitchen, a WC and a bathroom. House B, encircled with adjacent neighbour buildings in northwest, northeast, southwest and Muallak Alley in southeast directions. The two storey block, used during hot period, situated on the southwest part of the plot and one storey block, situated on the northeast part, used during the cold period, separate the courtyard from the neighbours. A pool...
and a water well are on the courtyard and a WC, a bathroom, a kitchen, an eyvan and five rooms comprise the blocks of the house. House C, encircled with neighbour buildings in all directions, has a courtyard combining a two storey summer block in south, a one storey winter block in northeast and a seasonal one storey block in west directions. A bigger pool, a water well and two mulberry, two rose and one peach trees take place in the former pool. Blocks contain WCs, a bathroom, a kitchen, two eyvans and seven rooms. Although the exact production dates of houses cannot be found, it is thought that they have been used for 200 - 300 years.

Table 2. Spaces of Diyarbakır Houses

<table>
<thead>
<tr>
<th>Main Living Space: Courtyard</th>
<th>Semi-Open Living Space: Eyvan [19]</th>
</tr>
</thead>
<tbody>
<tr>
<td>WC [19]</td>
<td>Cool Room: Serdap [31]</td>
</tr>
</tbody>
</table>
The chosen houses are evaluated according to the water efficiency credits of LEED 2009 v3 LEED for Homes. Water efficiency category includes three main credits (Table 4) and min. 3 points are required for certification.

**Evaluation of houses with WE 1. water reuse credit**

Water reuse credit, without any prerequisites, evaluates a project according to its decisions about using municipal recycled water or offset central water supply through the capture and controlled reuse of rainwater and / or graywater.

In order to gain points, three options, which include a rainwater harvesting and storage system, a graywater reuse system or a system for using municipal recycled water system, organized
according to certain principles, are necessitated to be designed and applied. In three selected Diyarbakır houses, due to their construction dates, any of those organizations are not found and houses cannot take points in this credit.

<table>
<thead>
<tr>
<th>Table 4. Credits of water efficiency category</th>
</tr>
</thead>
<tbody>
<tr>
<td>LEED for homes water efficiency credits</td>
</tr>
<tr>
<td>WE 1. water reuse</td>
</tr>
<tr>
<td>1.1. rainwater harvesting system and/or</td>
</tr>
<tr>
<td>1.2. graywater reuse system or</td>
</tr>
<tr>
<td>1.3. use of municipal recycled water system</td>
</tr>
<tr>
<td>WE 2. irrigation system</td>
</tr>
<tr>
<td>2.1. high-efficiency irrigation system and/or</td>
</tr>
<tr>
<td>2.2. third-party inspection or</td>
</tr>
<tr>
<td>2.3. reduce overall irrigation demand by at least 45%</td>
</tr>
<tr>
<td>WE 3. Indoor Water Use</td>
</tr>
<tr>
<td>3.1. high-efficiency fixtures and fittings</td>
</tr>
<tr>
<td>3.2. very high efficiency fixtures and fittings</td>
</tr>
<tr>
<td>total</td>
</tr>
</tbody>
</table>

Evaluation of houses with WE 2. irrigation system credit

Irrigation system credit, without any prerequisites, evaluates a project according to its decisions about minimizing outdoor demand for water with a water-efficient irrigation system.

In order to gain points, three options, which include the design and application of a high efficient irrigation system, bearing certain qualities, third party inspection of this system or documentation of the reduction of overall demand by at least 45% via calculations done by certain specialists, are necessitated. The selected Diyarbakır houses, due to the lack of specified system and corresponding inspection or documentation, cannot gain any points in this credit.

Evaluation of houses with WE 3. indoor water use credit

Indoor water use credit, without any prerequisites, evaluates a project according to its decisions about minimizing indoor demand for water through water-efficient fixtures and fittings.

In order to gain points, average flow rate of lavatory faucets, showers and flushes for toilets, used in a project, are necessitated to meet certain levels. In the selected Diyarbakır Houses, any sinks or lavatories, therefore any faucets, showers or flushes for toilets can be found mainly because of the absence of the technological possibilities in the era during which the houses were built. Consequently, houses cannot gain any points in this credit.

FINDINGS AND DISCUSSION

The evaluation results of three Diyarbakır houses under the water efficiency credits of LEED 2009 v.3 LEED for homes show that houses cannot obtain any points (Table 5).

The LEED for homes rating system assesses projects under eight categories and works by requiring a minimum level of performance through in each of these categories. The result level is determined according to the number of points earned and for certification (minimum level) points between 45-59 are required. The research project results show that, three Diyarbakır Houses, selected due to presumptions in which a very high level could have been obtained through a suitable assessment system based on their sustainable and environmental properties, only received around 20 points in total which are not enough even for the minimum certification.
level. For this reason it is believed to examine the water efficiency LEED credits within the scope, aim and hypothesis of this paper should be beneficial.

Table 5. Evaluation of Diyarbakır houses

<table>
<thead>
<tr>
<th>LEED for homes water efficiency</th>
<th>LEED points</th>
<th>evaluation of Diyarbakır houses</th>
</tr>
</thead>
<tbody>
<tr>
<td>WE 1. water reuse</td>
<td></td>
<td>house A</td>
</tr>
<tr>
<td>WE 1.1 max.</td>
<td>4 points</td>
<td>0</td>
</tr>
<tr>
<td>WE 1.2</td>
<td>1 point</td>
<td>0</td>
</tr>
<tr>
<td>WE 1.3</td>
<td>3 points</td>
<td>0</td>
</tr>
<tr>
<td>WE 2. irrigation system</td>
<td></td>
<td></td>
</tr>
<tr>
<td>WE 2.1 max.</td>
<td>3 points</td>
<td>0</td>
</tr>
<tr>
<td>WE 2.2</td>
<td>1 point</td>
<td>0</td>
</tr>
<tr>
<td>WE 2.3 max.</td>
<td>4 points</td>
<td>0</td>
</tr>
<tr>
<td>WE 3. Indoor Water Use</td>
<td></td>
<td></td>
</tr>
<tr>
<td>WE 3.1 max.</td>
<td>3 points</td>
<td>0</td>
</tr>
<tr>
<td>WE 3.2 max.</td>
<td>6 points</td>
<td>0</td>
</tr>
<tr>
<td>total</td>
<td>15 points</td>
<td>0</td>
</tr>
</tbody>
</table>

Due to the lack of modern rainwater harvesting and storage, graywater reuse, municipal recycled water using, high-efficient irrigation systems or water-efficient fixtures and fittings, Diyarbakır houses cannot obtain any points through the evaluation under LEED for homes water efficiency credits. Despite this, households mostly obtain clean water from water wells in the courtyard or from city fountains for cleaning activities; use the city hamams for bathing. The clean water required for washing dishes, cleaning the house or for toilet activities, is carried with buckets and the waste water from these activities is used for other water required deeds such as irrigation of the courtyard and green spaces. Furthermore, the historical sewer system of the settlement nourishes the productive Hevsel Gardens enclosing the city in south and east directions through its way to Tigris River. Also, using waste water for cooling and humidifying the hot and arid air of living spaces and porous flooring design for this purpose can be considered as a logical solution which does not consume energy for user requirements originating from environmental factors. Considering the possibilities and conditions of the era in which the houses were built, the lack of points in spite of sustainable properties that correspond to the aims of the credits, can be interpreted as the deficiency of

- a proper evaluation method for traditional / existing / reusable buildings,
- questioning and examining regional and vernacular conditions and design decisions executed to meet the requirements rising from these factors,

in environmental-friendly building certification systems, which may procreate a discussion about the efficiency and qualification of the credits.

CONCLUSION AND SUGGESTIONS

The properties related to process of a building, which include the production, usage and after use stages, can be defined according to the effects of design decisions and production on natural, built and social environments of building indoors and outdoors. Therefore, by considering these effects during design stage of a built environment, positive outcomes can be managed in terms of environment and user, even regenerative solutions can be found. With proper assessment methods, such effects should be questioned within a logical and integrated system to examine the relationship of building with its environments.

In many parts of the world, for centuries, inherited public experiences have produced sustainable buildings and settlements which can still be used, are specified as compatible with modern
environmental, even regenerative approaches in terms of relations with physical and social environments, resource consumption, pollution and health. These examples were produced considering all the environmental factors: the users, natural / built environment and production resources such as products, energy and labour; they were formed over environment friendly, logical and convenient design decisions not only for production, but also for usage and after-use stages. In spite of this, especially after the industrial revolution, it is widely known that, modern societies have been producing built environments which have negative effects on their users and environments mainly because of ignoring these principles and solutions. Although eco-friendly approaches generated differences and raised awareness with many environment impact and life cycle assessment and certification methods, the development affords for these systems continue.

One of pioneers of these methods, LEED, including different assessment tools for building functions and properties, basically assesses the design team and strategies, properties of the site, water efficiency, energy consumption, some properties about quality and quantity of wastes, quality of indoor environment and education of users of a building. In the research, three houses of old Diyabakır Settlement is evaluated in terms of water efficiency by using LEED 2009 v.3 LEED for Homes certification tool. These houses, constituting three different types according to the placement of the courtyard and blocks for hot, cold and seasonal periods, were produced in regard to the environmental factors such as the circadian rhythm of the sun rays, outdoor air properties, prevailing wind, social properties of the user and features of the existing built environment. Although it can be observed that, the building form, architectural organizations and decisions are effective for meeting all the requirements of the user emerging due to these factors without consuming energy, producing waste or wasting water; the results of the evaluation show that final scores of the houses are below the lowest level required for certification and under water efficiency category, houses cannot obtain any points. It can be indicated that, the main reasons of this outcome are

- the examination of some features of utilizable buildings with an old production date, such as properties of fittings and fixtures, is impossible due to lack of these systems or documents related to them,
- many important design features, which procreate environment friendly solutions in terms of regional and local environmental properties, can be assessed only under a limited number of categories and points obtained with these features are in a low percentage,
- some modern electrical equipments, such as rainwater harvesting and storage, graywater reuse, irrigation systems are becoming mandatory without regarding environmental factors, however,
- architectural and social solutions, which can manage the aimed properties without consuming energy – such as reusing waste water for less important water required activities, nourishing green spaces with waste water by a wisely designed sewer system, and supplying required humidity with proper architectural design – are not included in the assessment system.

Based on these statements, for LEED assessment and certification system, which is the pioneer of similar tools, ensured the environment friendly concept become widespread and caused a certain decrease in energy consumption and a significant increase in terms of users’ health and comfort, it is suggested that,

- a proper subcategory can be constituted for buildings, which are produced in the past but still bearing properties eligible for using and eventually can help preserving and sustaining existing built environment and avoiding many building wastes and costs,
- the assessment tool can be reorganized based on a more balanced system which considers and involves different regenerative solutions in terms of regional and local environmental factors,
during the evaluation, instead of examining only the consumption of energy and water in production and usage stages, the interaction between the building and its environments can be questioned in terms of consumption of resources, production of pollution, health of user and environment during all stages of building under a more holistic approach.

In this study, it is believed that, rather than focusing on a single building and its performances which is the basic property of environment friendly approaches, a more integrative thinking and analysing way, especially suitable for regenerative concept, has been followed. By examining similar vernacular buildings that constitute successful examples in future studies, different properties and recommendations can be revealed for development of assessment tools.

REFERENCES


