

The Effectiveness of Shading Devices in Qatar University Campus

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DOI: [10.36348/SJEAT.2019.v04i10.006](https://doi.org/10.36348/SJEAT.2019.v04i10.006)
Received: 20.08.2019 | **Accepted:** 27.08.2019 | **Published:** 30.10.2019

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Abstract

The research study investigates the effectiveness of solar management techniques on the outdoor thermal comfort in hot, arid climates within the context of higher educational facilities. Qatar University in Doha, State of Qatar, is establishing the contextual unit of analysis as it provides a case study for urban planning and design within an educational environment. The campus has dynamic outdoor spaces that have been treated using urban strategies and techniques to create the most desirable environment for its vast range of users including students, faculty and staff members. The aim of the study is to assess the effectiveness of the current solar management techniques at Qatar University campus based on user's satisfaction. Therefore, the focused scope of analysis is targeting the shading devices that are found in the campus, which has been generally categorized as pedestrian shaded pathways with detached canopies and car parking shading structures. The thesis targets the following question: does the current shading devices on campus provide a satisfactory experience for users in addition to encouraging walkability and better utilization of outdoor spaces? By investigating the effectiveness of solar management techniques, it is possible to optimize the use of the current shading devices by relating their effectiveness to users' satisfaction and thermal comfort. Based on the methodology of survey analysis, a sample of fifty questionnaires has been collected and analyzed with reference to the existing users of the campus. The survey questionnaire is reinforced by further direct impressionistic observation as a verifying methodology. Results obtained from both methods of analysis are indicating the ineffectiveness of the current solar management techniques represented by shading devices in the campus of Qatar University, however supported by numerous applicable suggestions for improvement.

Keywords: Outdoor Thermal Comfort, Solar Management Techniques, Shading Devices, Qatar, Doha, Hot Arid Climate, Qatar University Campus, Campus Planning.

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INTRODUCTION

The investigation of the effectiveness of solar management techniques on the outdoor thermal comfort in Qatar University campus is a two-fold topic of research. It directs attention to the physical urban environment by examining elements of the outdoor space, specifically shading systems and solar management techniques. While the second direction is aiming at assessing user's satisfaction of the current outdoor shading systems based on the methodologies of survey questionnaire and direct impressionistic observation [1, 2].

The context of the research study is limited to higher educational facilities represented by the unit of analysis, Qatar University campus in Doha. It provides a case study for urban planning and design within the

outdoor spaces of an educational environment as a dynamic typology of urban setting. Outdoor spaces should be treated using proper urban strategies and techniques to create the most desirable environment for the vast range of users including students, faculty, and staff members.

The aim of the research study is to assess the effectiveness of the current solar management techniques in Qatar University campus based on user's satisfaction. The concept of effectiveness relates to the degree at which something is successful in producing a desired result, as a dictionary citation [3]. Measurement of a perceptual, subjective quality such as effectiveness or success requires public consensus rather than exact, numerical results. Thus, there has been a little mention in the literature of subjective aspects that could measure urban qualities related to solar management techniques.

However, the greatest share of literature is given to topics calculating thermal comfort for its direct capability of being measured and technically confirmed [4, 5].

Within the research study, the focused scope of analysis is targeting the user's level of satisfaction of the shading devices found in the campus, which has been generally categorized as pedestrian shaded pathways and car parking shading structures. The thesis, respectively, targets the following question: does the current shading devices on campus provide a satisfactory experience for users in addition to encouraging walkability and better utilization of outdoor spaces? By investigating the effectiveness of solar management techniques, it is possible to optimize the use of the current shading devices by relating their effectiveness to users' satisfaction and thermal comfort in the outdoor space.

Based on the methodology of survey analysis, a sample of fifty survey questionnaires has been collected and analysed with reference to the existing users of the campus. In addition, direct impressionistic observations are collected as a verifying tool to further support the results collected by the survey. The combination of qualitative as well as quantitative data adds richness to the research process to justify the effectiveness of shading devices in the campus of Qatar University.

The results obtained from both methods of analysis are indicating the ineffectiveness of the current solar management techniques represented by shading devices in the campus of Qatar University, however supported by numerous applicable suggestions for improvement. Shading devices can be upgraded in their function and quality by considering the climatic context as well as their own design parameters. The conclusion of the research study is presenting a list of suggestions gained through the methods of data collection as insightful feedback from the end-users.

LITERATURE REVIEW

The surrounding environment has a tremendous effect on the way people live and act on daily basis. These factors can be related to climatic conditions, density of urban construction and size of green areas [6, 7]. Due to rapid urban developments in many parts of the world and more specifically in the Arab Gulf countries, the characteristics of urban microclimates have been considered for their dramatic influence on the satisfaction of pedestrians especially in hot dry climates [8-10].

Thermal comfort in hot arid areas is one of the complex issues in urbanization due to its dependence on many factors such as air temperature, humidity, air movement, thermal radiation and the level of clothing. The theoretical comfort models assess the impacts of

these factors on the thermal balance of the human body irrespective of adaptation to the local climate. People expectations when they go outdoor are related the variability of exposure levels to different conditions such as variation in sun and shade, modification in wind speed and direction and changes in humidity levels [8, 11, 12].

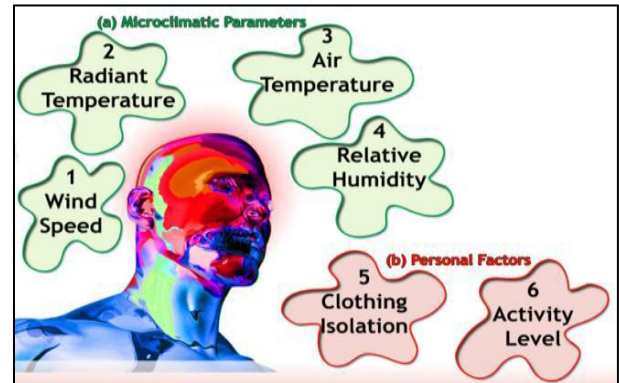


Fig-1: Thermal comfort interaction factors

Several techniques and methodologies have been suggested for indoor and outdoor solar and thermal effect mitigation. Figure 2 shows a summary of these methodologies as reported in the literature [13, 14].

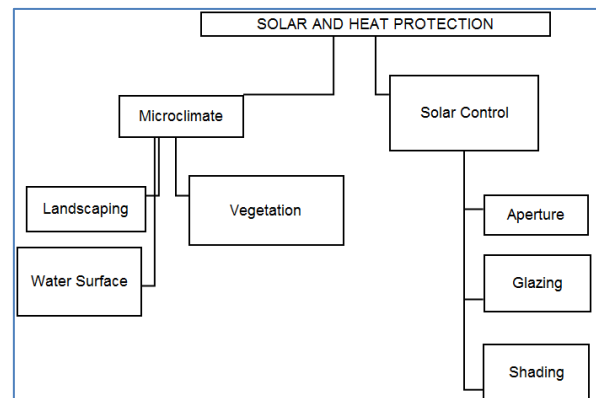


Fig-2: Thermal shading techniques for solar and heat protection

This literature review is shedding light on the main outdoor thermal and solar protection devices as well as the main measures proposed by different researchers on how efficient they are for human satisfaction. Focus is on methodologies and techniques that are of great interest to areas of hot dry or humid nature similar to the conditions in the Arabian Gulf region, specifically considering the climatic context of the state of Qatar.

Thermal Comfort Techniques

Microclimate

Microclimate is defined as the variation in localized climate around the building due to the presence of hills, valleys, streams, slopes or other buildings [13]. Several methods have been proposed to overcome or minimize thermal and solar effects via the

management of microclimate factors as will be shown in the following sections.

Landscaping

Urban landscaping in hot humid areas are often exposed to high intensity of solar radiation which contributes to overheating due to low evaporation rates and increasing heat gain [15]. Researchers from

Malaysia have investigated measurement studies on the effect of morphological aspect on the microclimatic condition in location of various urban landscapes morphology in Putrajaya, Malaysia. Their results showed that urban landscape morphology strongly influenced microclimatic conditions in the study area which of hot humid climatic nature [15].

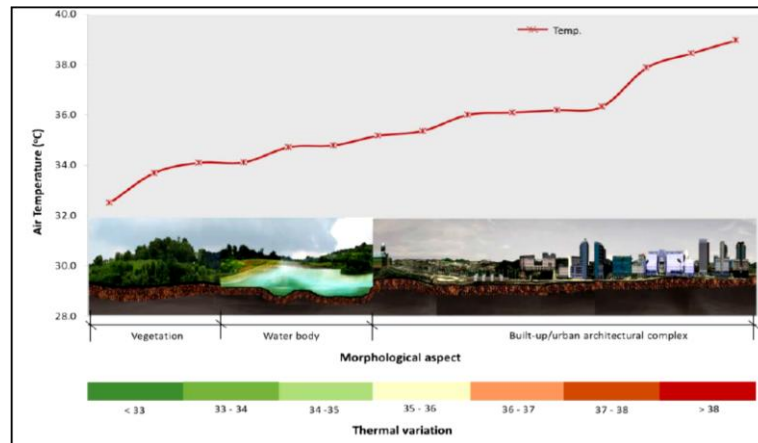


Fig-3: Thermal variation and morphological aspect

In an another interesting research that have been reported recently by de Abreu-Harbach *et al.* [16], the daily and seasonal microclimate behaviour of 12 various tree species with different planting design were quantified in the southeast of Brazil to investigate whether certain vegetation used for shading public and private areas have an influence on thermal comfort in the cities. The results show that shading of trees can influence significantly human thermal comfort. The species *C. Pluviosa* F. presents the best possibility in

terms of the psychological equivalent temperature index (PET) because it can reduce between 12 and 16°C for individual trees clusters [16].

Solar Control

Some of the mitigation techniques to minimize and utilize the solar flux on the buildings have been studied and reviewed for the utilization of solar power in energy as well as for comfort of human beings (Dubois, n.d.)(Deroisy, Deneyer, & Flamant, n.d.) [17].

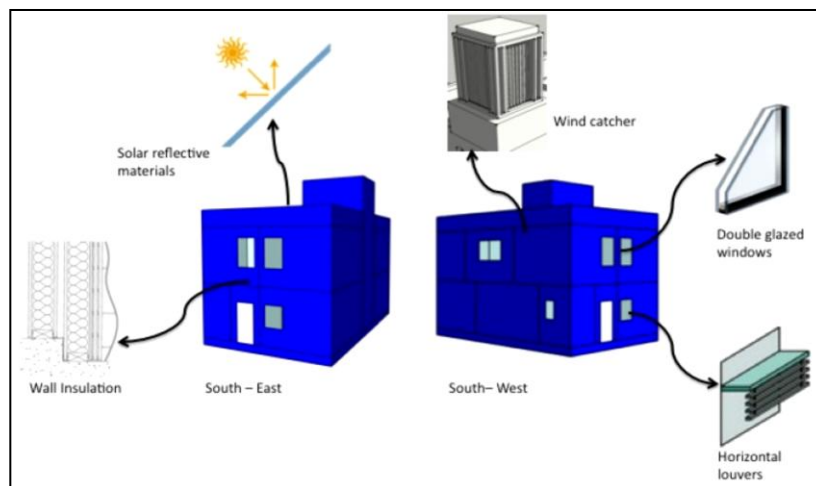


Fig-4: Adopted passive cooling design strategies

Glazing

In a recent study by Al-Saffar [18] to evaluate passive cooling strategies in greening existing residential buildings in the Kingdom of Bahrain as a case study of a hot arid area, it has been shown that

most heat gain or losses come from windows and openings in buildings. Therefore, the use of double-glazed windows achieved dramatic changes in energy reduction in the indoor environment. Moreover, single

glazing is less efficient than double glazing having 12 mm cavity containing Argon gas for better insulation.

Shading

Although many passive cooling techniques have been proposed in literature, it has been demonstrated that solar shading of buildings especially in developing countries is of great interest due to their efficiency, easy implementation and low cost [20,19, 21, 22]. In hot arid areas in rural India and developing countries in the Middle East region, masonry houses roof tend to make the indoor temperature very high

around 41°C due to high roof top temperature of around 65°C in these regions. Solar shading with locally available materials like terracotta tiles, hay, inverted earthen pots, date palm branches etc. can reduce this temperature significantly. Another easy cheap method for solar shading is the use of trees which reduces ambient temperature near outer wall by 2°C to 2.5°C. In addition, the design of effective shading devices such as the overhangs, louvers and awnings is very effective at shading south-facing windows in the summer when sun angles are high.

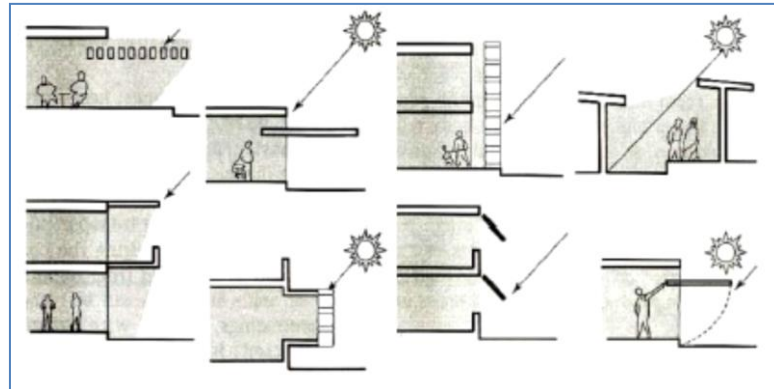


Fig-5: Different types of shading devices

Measures of Thermal and Solar Shading Efficiency

In order to evaluate the effectiveness of solar and thermal comfort techniques, researchers have attempted to design models that can estimate the comfort conditions that people find acceptable outdoors [8]. This section will introduce the main models proposed in this field:

SET* Index

The new effective temperature (ET*) is based on human energy balance and two-node model as proposed by Gagge *et al.* [23]. With ET*, the thermal conditions can be compared to the conditions in a standardized room with a mean radiant temperature equal to air temperature and a constant relative humidity of 50%.

Extended PMV Index

Fanger [24] has developed the predicted mean vote (PMV) as an index for rating thermal discomfort

for indoor climates at various states of activity and clothing insulation. PMV is also used as ISO 7730 indicator. In Table 1, the relation of PMV value with thermal perception and physiological stress level is shown for low activity and normal indoor clothing along with the PET index for the same categories.

PET Index

The psychological equivalent temperature index (PET) was first proposed by Hoppe in 1999 [25]. It is equivalent to the air temperature at which the heat balance of human body is maintained with core and skin temperature equal to those under the conditions to be assessed. The heat balance of the human body in this case included the work metabolism of light activity added to heat resistance of clothing.

Table-1: Ranges of PMV and PET indices for different grades of thermal perception and psychological stress

PMV	PET (C)	Thermal Perception	Grade of Physiological Stress
		Very cold	Extreme cold stress
-3.5	4	Cold	Strong cold stress
-2.5	8	Cool	Moderate cold stress
-1.5	13	Slightly cool	Slight cold stress
-0.5	18	Comfortable	No thermal stress
0.5	23	Slightly warm	Slightly heat stress
1.5	29	Warm	Moderate heat stress
2.5	35	Hot	Strong heat stress
3.5	41	Very hot	Extreme heat stress

Thermal Comfort Analysis for the First Passivhaus Project in Qatar

The Passivhaus standard is a well-established energy efficient standard, initially developed as a construction for concept for residential buildings in Central Europe, but in the past 25 years, it has been adopted for many areas around the world for different types of buildings [26]. Table 2 present the standards of Passivhaus.

Table-2: Passivhaus standards

Criteria	Requirement
Heating Demand	Specific space heating demand ≤ 15 kWh/(m ² a) Or alternatively: heating load ≤ 10 W/m ²
Cooling Demand (including dehumidification)	Total cooling demand ≤ 15 kWh/(m ² a) + 0.3 W/(m ² aK).DDH Or alternatively: cooling load ≤ 10 W/m ² AND cooling demand $\leq 4 / (kWh/m^2aK) \times 9e + 2 \times 0.3$ W/(m ² aK) x DDH – 75 kWh/(m ² a) but not greater than: 45 kWh/(m ² a) + 0.3 W/(m ² aK) x DDH
Total Primary Energy	Energy demand ≤ 120 kWh/(m ² a)
Air tightness	Pressure test result, n50 ≤ 0.6 h-1
Thermal Comfort	Thermal comfort must for all living areas year-round with not more than 10% of the hours in any given year over 25°C

Due to the success of the Passivhaus standard in thermal comfort, this has attracted the attention of architects and engineers around the world, including Qatar. Qatar has recently announced the first Passivhaus project in the MENA region. In order to evaluate the environmental performance of Passivhaus in hot arid areas, the project included two villas that have been constructed side-by-side, one according to the Passivhaus's standard and the other according to conventional construction practices in the country. The performance of the two villas has been analyzed focusing on the indoor thermal comfort that the indoor temperature and relative humidity which were the main indicators of occupant comfort levels.

Annual hourly data and detailed analysis of the occupied spaces in both villas on the typically hottest and coldest days of the year was undertaken. The findings indicated a consistent and more uniform level of comfort in the Passivhaus-model compared to the standard base model which can be an initial indicator for the applicability of Passivhaus to mitigate thermal discomfort in hot areas [26].

Passivhaus and indoor thermal comfort

As it has been analyzed through the literature review, thermal comfort in hot arid areas has been an active topic of research in the field of climatology and urban design. Different techniques have been proposed to mitigate the increase in temperature for indoor and

outdoor environments. Among the most applied methods are the use of window glazing, extend green areas and open landscaping as well as the application of various types of solar shading technologies. In order to evaluate the efficiency of different thermal shading techniques, several indices have been proposed. The main indices used are the psychological equivalent temperature index (PET), the predicted mean vote index (PMV) and the standard effective temperature (SET*) index. Relating the various well-known techniques for thermal comfort to the applied context of Qatar, a recent project has been commissioned to evaluate the standards for Passivhaus as a first project of its type in the Middle East region. The preliminary results indicate that Passivhaus has provided indoor thermal comfort in terms of consistent temperature and rate of humidity. Such standards could be used as the main criteria to evaluate thermal comfort in the outdoor spaces.

THE RESERACH DESIGN

The adopted methodology is embedded within a combination of inductive and deductive methods gained through survey questionnaire and participatory observations. The variety of methods enriches the research process, in addition to obtaining multiple feedback methods to achieve the most reliable results considering the study of a qualitative urban design element such as solar management techniques in outdoor environments [27-30].

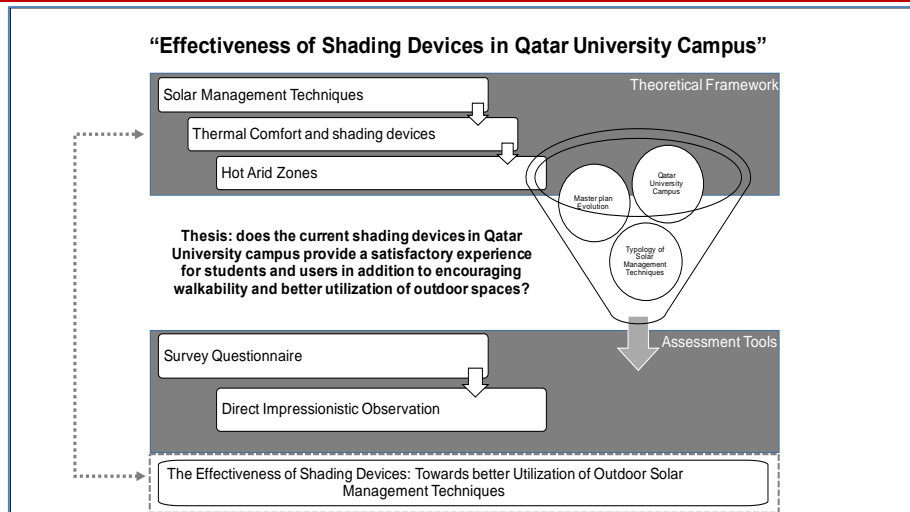


Fig-6: General Methodological Approach of the Research

The Context of the Research: Qatar University Campus

According to Qatar National Development Framework 2032 (QNDF), the national strategic hierarchy of centers proposes Qatar University as a new town center. Town centers “complement the Metropolitan Centers by serving catchments to down-wide significance and accommodating key employment concentrations [12,31]”. In this prospect, Qatar University is characterized by its core of high density and concentrated employment and communal activities,

considering the future growth management of the country. The urban development policies of Qatar are aiming at reducing the current fragmented urbanism and integrate special uses with other land uses to achieve a comprehensive master plan and therefore create the anticipated sustainable urban development. Thus, the development of Qatar University as a town center will be planned in consideration of Qatar University’s master plan and further legacy opportunities attracted to the country.

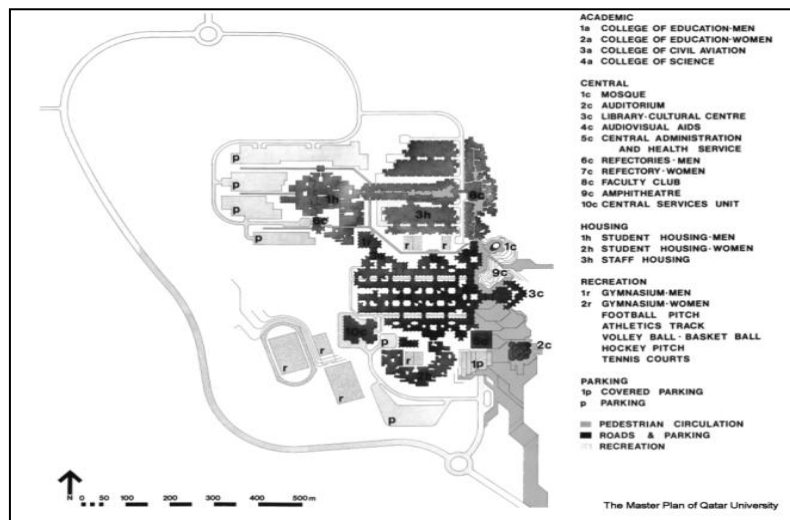


Fig-7: Initial master plan concept of Qatar University

The master plan of Qatar University campus has been evolving ever since the first project was initiated by UNESCO sponsorship in the 1970s and completed in 1985. The initial master plan has the concept of a ring road surrounding the main campus and other facilities. All the academic buildings are planned within the ring road with sports and ancillary facilities to the outside. The concept for high quality concrete buildings in a modular low-rise form has allowed the use of repetitive precast elements for both

cladding and structural walls. The layout of the academic buildings is based on two grid forms, an octagon 8.4 m in width and a square with sides of 3.5m. The octagons are adjacent and connected with squares to form the modular grid pattern [32].

At present, Qatar University master plan is witnessing a vast growth to include additional academic buildings, library, administration services, and sports facilities, in addition to social and recreational centers.

Its main campus is built with architecture that is distinguished and modern, while reflecting the ideals of traditional Islamic design. The campus is divided into two adjacent sections for male and female students.

Both the men's and women's campuses have their own separate lecture halls, laboratories and learning support services [4].

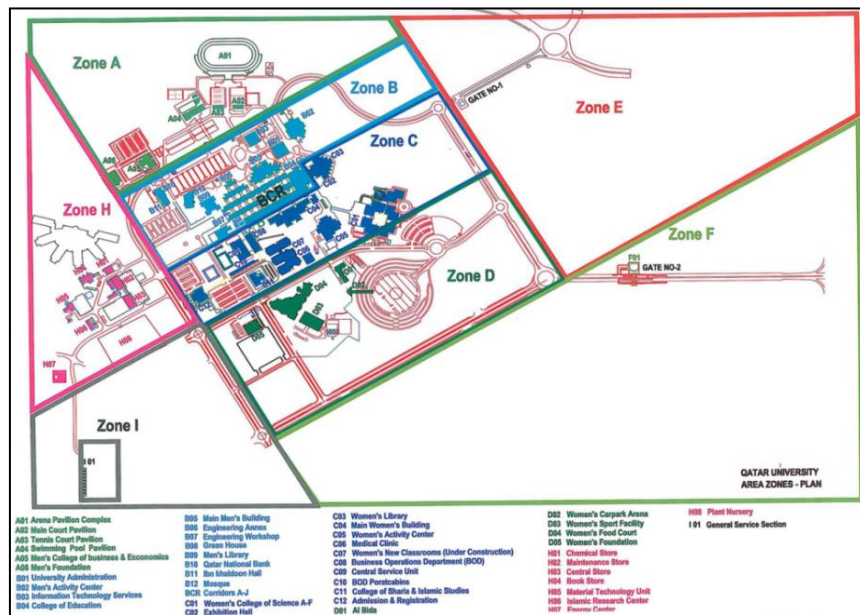


Fig-8: Current Qatar University Zones Layout Plan

The core of the master plan is kept as it is in the origin state with growth of the overall area to cover almost 8 square kilometres. The master plan is divided into nine zones with unplanned areas, each of which is designed separately. Among one of the unplanned areas is a proposal of the new investment zone, located on the north eastern corner of the master plan. The new investment zone is expected to have high-end residential units, towers, and other privately-owned facilities that aim at generating revenue to Qatar University as a landowner. The design of the new investment zone is following a commercial sub-urban approach, with a hierarchical formative order of units separated by a major access route.

Immediate needs for growth of Qatar University have generated over time a state of confusion with a series of new additions and extensions appearing on site. Although the existing condition is attempting to rationalize the site through the construction of new access roads and facilities such as new college buildings, the overall master plan falls short of creating organization or providing a framework for future expansion and growth.

Typology of Solar management Techniques in Qatar University Campus

Considering the phased progress of the master plan of Qatar University campus, which is characterized

by the fragmentation of buildings and the expansion of the main campus toward vacant lands, there has been a need to create a linkage between different land uses to support accessibility and user's comfortable flow around the campus. Such temporary linkage should have been considered as a permanent strategy during the planning process to achieve the best criteria for treating the outdoor urban space. As an ideal approach, the outdoor areas in campuses "should not be treated as leftover spaces between buildings and a special attention should be given to plan development [33]".

In the context of Qatar University campus, integration of buildings as well as the connectivity between different land uses is achieved by utilizing outdoor solar management techniques including detached shading devices. It is important to mention that the concept of shading devices relates to a wide range of types. A typical shading device includes two basic elements of a supporting frame and a shading awning resting on the frame. The focused scope of analysis of this paper is targeting outdoor shading systems of canopies, detached awnings and parasols that either provide fixed shade or define pathways. As a general observation, shading devices that are utilized in the campus belong to two broad categories: Pathway Shading Devices (Figure 9) and Parking Shading Devices (Figure 10).

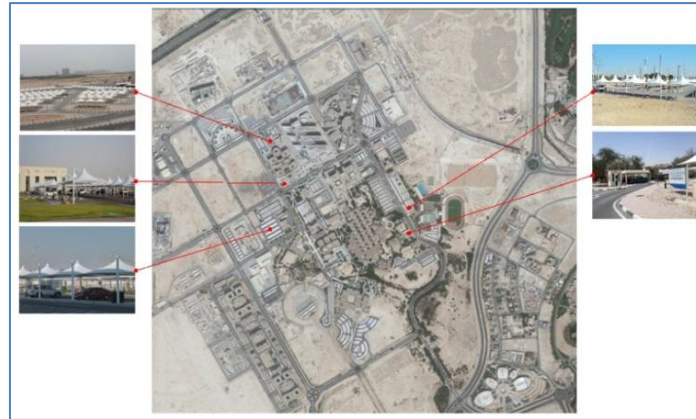


Fig-9: Pathway Shading Devices in Qatar University Campus

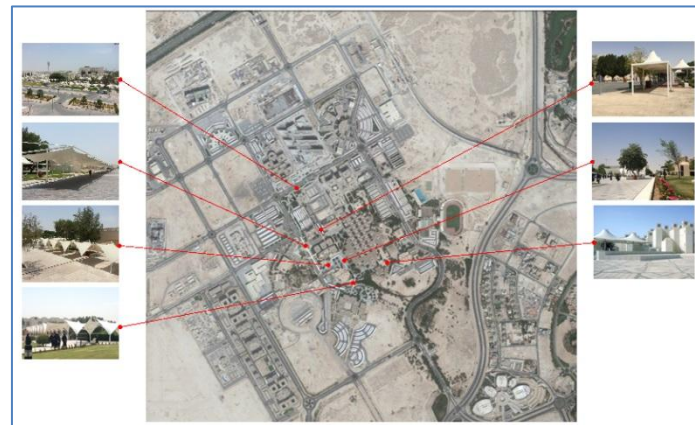


Fig-10

A major preliminary remark suggests that most of the utilized pathway shading devices is new to the campus. They concentrate around the newly built college buildings in the female section, where fragmentation of buildings is highly dominant. However, within the male campus few alterations or additions of solar management techniques are found since male students are still utilizing the old, octagonal-grid building of Qatar University.

Methodology of Survey Questionnaire and Direct Impressionistic Observation

A multi-layered methodology is developed in this research to ensure a collective overview of the studied aspects that would support the process of obtaining the most reliable conclusions. The main research methodology employed in this study is the survey questionnaire, which targets current users of the outdoor spaces in the campus primarily including students, faculty and staff. Based on the results of the survey, selected shading device locations are marked as key outdoor spaces for further investigation [34]. The key outdoor spaces are exposed to direct impressionistic observation where the behaviour of the users are spotted considering the attribute of shading and the analysis of spontaneous interaction of users with such urban solar management technique. Supported by images and systematic observation, the selected key locations are evaluated in parallel to the obtained results from the

survey as well as reflected on the hypotheses of the research.

Survey Questionnaire

A survey questionnaire is designed to target the effectiveness of the shading devices in Qatar University campus with seventeen questions including selection from options, agreement on statements and descriptive questions that require the participant to note their impressions and suggestions. The survey is prepared via a professional online software, namely Typeform®, which is interactive and possible to be accessed via smartphones and tablets to ease the survey distribution process (see appendix A).

The most important issues targeted by the survey are the outdoor spaces in the campus and the factors that contribute to higher user satisfaction of the outdoor spaces, issues of walkability, average walking distance, reasons for walking and limits of walkability in the outdoor spaces of the campus. In addition, questioning the shading device effectiveness is of a high priority to the study, as it assesses the users' perception of the need for shading devices; most utilized locations of the shading devices based on a selection from images; and the most effective purpose of shading devices. Further detailed questions target the most important characteristics that would increase the effectiveness of shading devices from user's point of

view. An open question would require the participant to suggest ways for the improvement of the effectiveness of shading devices in the outdoor spaces of Qatar University campus. Collected responses and comments are viewed as personal reflections that would support the aim of the study targeting end-users of the shading devices.

Direct Impressionistic Observation

Based on the results of the survey questionnaire, further assessment of the effectiveness of shading devices in Qatar University campus is achieved by analysing key locations during limited time schemes to spot the pattern of users' flow. Through a series of images, photos and personal observations, the direct impressionistic method is expected to highlight the most important issues considering the effectiveness of the shading devices. Such results are supporting the quantitative data obtained by the survey questionnaire.

The two selected key locations are marked in the survey as one of the least and the most utilized shading device locations by users from the photo dialogue presented in the questionnaire sheet (see appendix B). The first location (A) is one of the least utilized shading device locations, which is found within Female Activity building pathway. Whereas the second location (B) is the most utilized location of shading

devices found in the pathway between Sharia Parking and College of Engineering.

DATA PRESENTATION AND ANALYSIS

Survey Questionnaire Results

A survey is conducted to investigate and measure the level of satisfaction on the existing shading devices in Qatar University campus and their effect on walkability and outdoor space enjoyment. The survey is divided into three major parts. Part one is related to the different categories of participants which include: gender, nationality and occupation at Qatar University. The second part is related to the level of satisfaction regarding outdoor enjoyment and more specifically on the aspect of walkability at Qatar University campus. The third part is focusing on the shading devices that are found around the campus and their effectiveness for their purpose of utilization.

Categorical Questions

The survey questionnaire is designed and distributed to a random sample of users of Qatar University campus. It targets a total of fifty-one participants belonging to general categories as shown in Table 3 below.

Table-3: Categories of participants in the “shading device survey” at Qatar University

	Category	Percentage (%)
Gender	Male	10
	Female	90
Nationality	Qatari	71
	Non Qatar	29
Occupation	Student	86
	Faculty	10
	Staff	4

As it has been indicated by the survey results, most of the participants are female students since they constitute the highest percentage of students in Qatar University by gender. In addition, the majority of the survey is conducted within the female campus of Qatar University where most of the shading devices are utilized. Considering the occupation of the participants, the student category is dominant as the main users of educational facilities, followed by limited number of faculty members and staff members.

Participant Enjoyment Level and Walkability in the Outdoor Spaces of the Campus

The second part of the survey focuses on the assessment of satisfaction levels of participants regarding walkability and the perception of enjoyment of outdoor spaces in the campus. Questioning the level of enjoyment of the outdoor spaces in Qatar University campus results in an average overall agreement of 3.24 on a scale of 5, with 1 representing “slightly agree” and 5 representing “highly agree”.

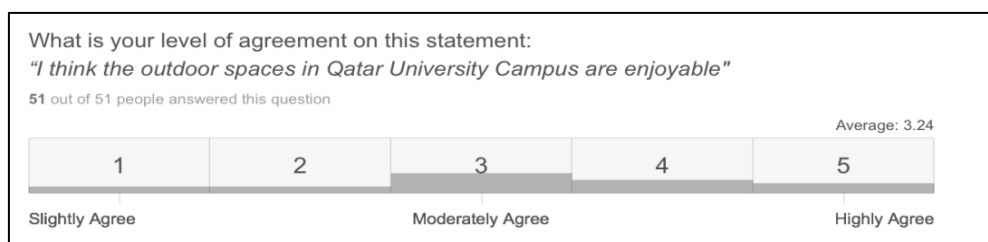


Fig-9: Participant Agreement Level "I think the outdoor spaces in Qatar University campus are enjoyable"

Moreover, about 75% of the participants express their enjoyment while walking in Qatar University campus while 18% disagree as indicated in Figure 12. Nevertheless, the average daily walking time when the participant arrives at the campus is around one to five minutes with a less percentage given to higher outdoor walking time. Questioning the participant reasons for walking outdoor, equal percentages (78-80%) are found to be related to three main reasons: to attend lectures at different buildings; to reach a

delivery/collecting point when arriving or leaving the campus; and to reach different services throughout the campus such as going to the library or the food court, etc. On the other hand, almost equal agreement percentages (39- 40%) are given to the reasons of socializing with friends or enjoying the weather, which might be specific to the period of the year where the survey is conducted. In other words, if the survey was conducted in the summer time, it is expected that little or no consideration will be given to this factor.

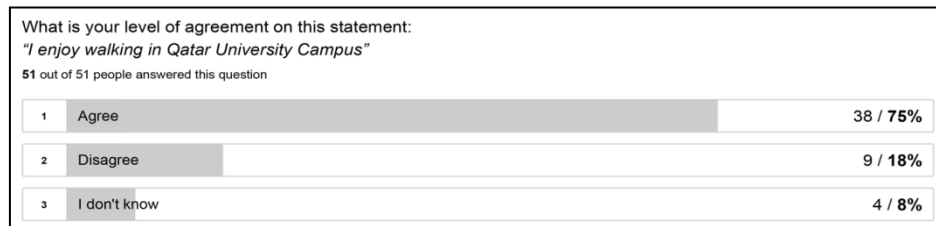


Fig-10: Participant level of agreement "I enjoy walking in Qatar University campus"

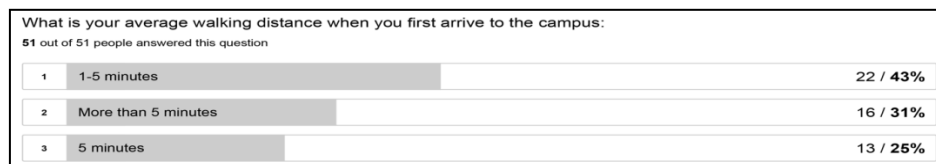


Fig-11: Average waiting time when first arriving to the campus

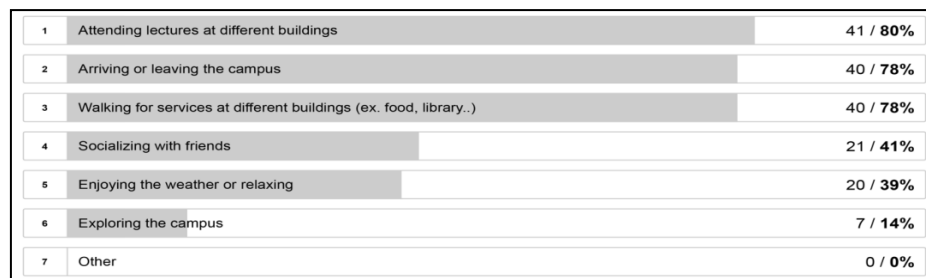


Fig-12: Reasons for walking outdoor in the campus

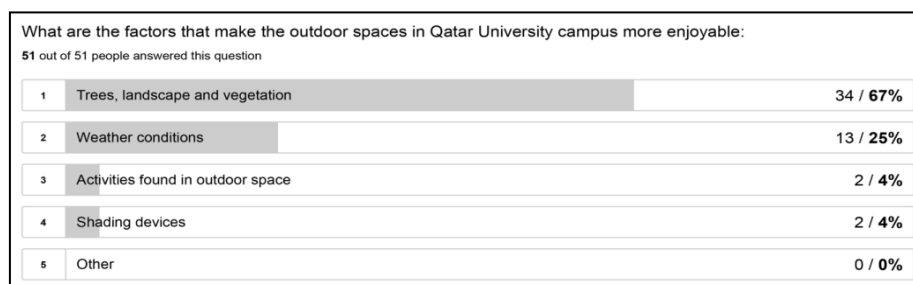


Fig-13: Factors contribute to higher enjoyment level in the outdoor spaces of Qatar University campus

In order to further assess the factors that contribute to higher levels of enjoyment of the outdoor spaces at Qatar University campus, participants are given a list of four primary factors including shading devices, which is the core factor of the research. The following responses are received as shown in Figure 15 below.

Around 67% of participants choose trees, landscape and vegetation as the main reasons that contribute to the outdoor enjoyment of Qatar University

campus, while 25% believe it is the weather condition that has the major effect, meaning that in winter, the outdoor spaces are more attractive and enjoyable compared to summer times. However, a very little reasoning is found to be related to outdoor activities or the availability of shading devices. Only 4% of the participants could see the connection between enjoyable outdoor environments and the utilization of efficient shading devices, which counts as an alarming score. A justification for this alarming score is expected to be related to the limited usage of shading devices so that

few of the participants could notice their direct effect on the outdoor environment. Another possible factor is the inefficiency of the current shading devices to mitigate

the effect of hot weather conditions, which falls short of providing an enjoyable walking experience throughout the campus.

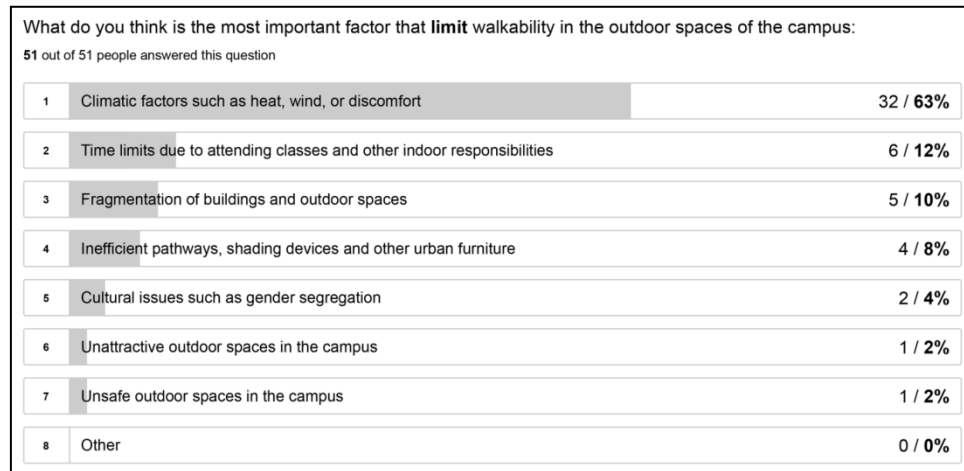


Fig-14: Factors limiting walkability in the outdoor spaces of the campus

The last question of part two is related to the walkability aspect and enjoyment of outdoor spaces in Qatar University campus. The question is designed to investigate reasons limiting walkability from the participant's point of view.

According to the results, climatic factors such as heat, wind or thermal discomfort is chosen by 63% of the total participants. This specific choice supports the hypothesis that shade and climatic moderation techniques are highly required to encourage walkability in hot, arid climates, which could be extremely hot and humid during summer or windy and dusty in winter time. In addition, considering the time unit of the survey that is carried out in winter, participants still believe it is the climatic factors that limits walkability throughout the year. On the other hand, medium to low agreement levels are achieved by the following three

factors: time limits due to attending classes or lectures; Distribution of buildings that might require a short walking distance; or the pathways planned and shading devices used around the campus are seen fairly efficient for regular walkability. The least chosen factors that limit walkability are the cultural issues such as gender segregation; the unattractiveness as well as the safety of the outdoor spaces of the campus.

The Effectiveness of Shading Devices at Qatar University Campus

In order to investigate the issues that contribute to the participant's unawareness of the shading devices as effective outdoor solar management techniques, this section of the survey is shedding light on the role, availability, type and effectiveness of shading devices in the context of Qatar University campus.

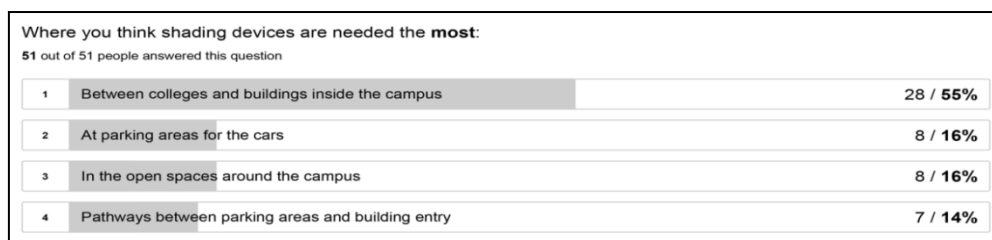


Fig-15: "Where shading devices are needed the most"

The purpose of the first question is to understand the necessity for the shading devices along with the participant's opinion on where such techniques are mostly needed. Referring to the previous section of the survey, it has been indicated that 80% of students would walk to reach other buildings throughout the campus for various reasons. Respectively, the question shows that the participants believe shading devices are mostly needed between colleges and buildings inside

the campus. Almost equal agreement levels are given to the need for such devices in parking areas; in open spaces around the campus; and in the pathways connecting parking areas to building entries. It is worth noting that although Qatar University suffers from major parking space problems, the currently designed parking areas are shaded and close to building entries in most of the cases, justifying the slight agreement given to these reasons as per the survey.

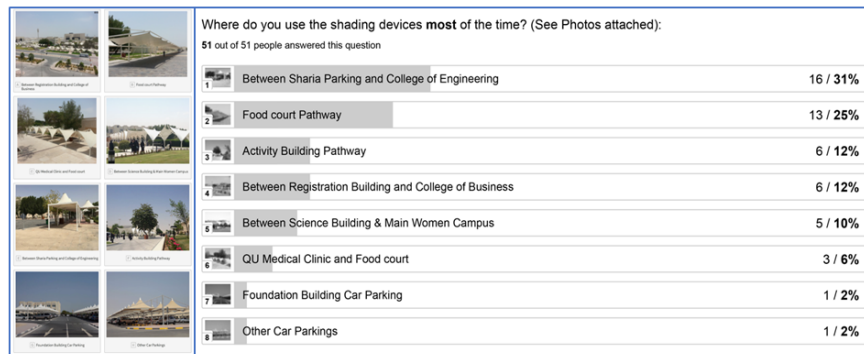


Fig-16: Most used locations of shading devices within Qatar University campus

According to urban planning practices, shading devices should be distributed throughout the campus based on systematic studies of location, connections, users, and climatic orientations. However, the following part of the survey is presenting a major challenge considering the lack of the appropriate availability of shading devices wherever they are required the most.

It can be clearly identified that the existing shading devices in some of the main outdoor spaces of the campus are unutilized or slightly utilized. Such

locations are critical for the daily use of students and their regular flow pattern. Among the key locations that lack proper usage of the shading devices are the registration building, the activity building and the medical clinic pathway. Nevertheless, 25 – 30% of the participants regularly use the shading devices at the food court pathway or between Sharia parking and the College of Engineering. Such figures do not clearly indicate the effectiveness of shading devices, but only reveal that the participants recall their availability in the indicated locations.

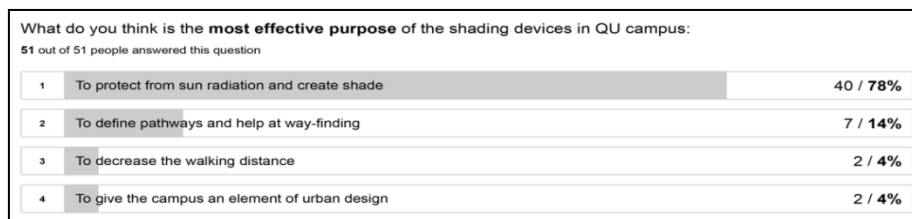


Fig-17: The most effective purpose of shading devices

The following question of the survey investigates the realization of the actual purpose of the shading devices in order to further evaluate their effectiveness. Most of the participants, 78%, agree that the ultimate effective purpose of shading devices is to provide protection from sun radiation and heat by creating shade over the location. This is indeed the actual, direct purpose of shading devices in the outdoor spaces. Furthermore, 14% of the participants believes that the main reason for using shading devices is to define pathways and help at way-finding. This choice is highly relevant to the context of fragmented urbanism similar to the trend found within the campus of Qatar University. Less agreement is given to the purposes of minimizing walking distance or giving the campus an element of urban design.

Questioning the most important characteristics that would increase the effectiveness of the shading devices, 31- 35% of the participants believe that the size of overhang and the orientation of the shading devices are the major characteristics that would contribute to an effective shading system. Meanwhile, 20% of the participants believe the material of fabrication would be more important. Technically and according to the literature review, higher effectiveness of shading devices can be achieved via a combination of factors related to the shading coverage area, material, and colour of reflection. However, in most cases, the area of shading is more relevant as it directly protects from sun, heat and radiation.

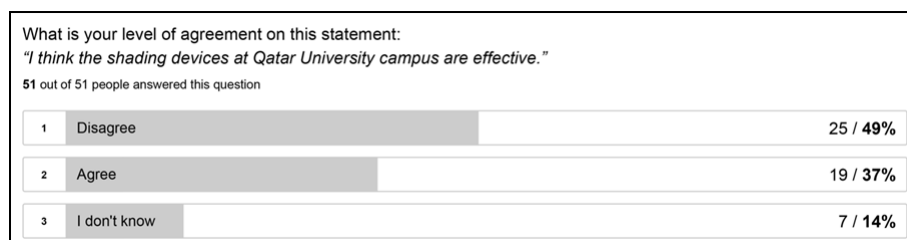


Fig-21: Overall agreement level of the effectiveness of shading devices in Qatar University campus

1	Size of the overhang (the horizontal element that provides shade)	18 / 35%
2	Orientation of the shading device	16 / 31%
3	Material (ex. fabric, timber, metal)	10 / 20%
4	Color of the shading device	6 / 12%
5	Other	1 / 2%

Fig-20: Most important characteristics that would increase the effectiveness of shading devices

On the overall satisfaction level of the effectiveness of shading devices, almost 50% of participants are dissatisfied with the current shading devices available in Qatar University campus and believe the current system is inefficient. This is seen as a result of several factors investigated as per the detailed questions of this survey. The lack of properly installed shading devices in critical locations such as the main building entrances; the design failures of the current shading devices in terms of orientation, size and area; and the limited walkability options found in the campus are amongst the main factors contributing to the dissatisfaction of the survey participants. Nevertheless, around 37% of the participants thought that the shading devices in Qatar University campus are effective, with the remaining 14% unsure whether the devices are effective or not.

Concluding Remark

This survey is conducted to investigate user's satisfaction of the shading devices used in the outdoor spaces of Qatar University Campus. Based on the responses received from fifty-one participants, mainly Qatari female students, a number of conclusions are obtained assessing the effectiveness of shading devices. In general, the answers show a general lack of attention

paid to outdoor solar management planning at Qatar University and more specifically on the appropriate distribution of effective shading devices. This fact is reflected on the time spent by the participants to enjoy outdoor spaces within the campus or walk from one place to another, although the outdoor environment is generally perceived as enjoyable. Considering the climatic aspect, more attention should be given to the utilization of solar management techniques that provide proper protection and enhance thermal comfort.

The survey questionnaire uncovers the significant need for a mutual cooperation between urban planners of Qatar University campus, stakeholders, and users of the campus to adopt projects where more efficient shading devices are properly utilized in the several outdoor locations of the campus. Such devices, although critical for thermal shading, need to be carefully studied in terms of appropriateness and system of shading to fit the context of an educational facility. The proper allocation of shading devices and providing the right context for their urban utilization would increase the level of outdoor enjoyment, encourage walkability and create a comfortable outdoor experience for campus users.

Direct Impressionistic Observation Results

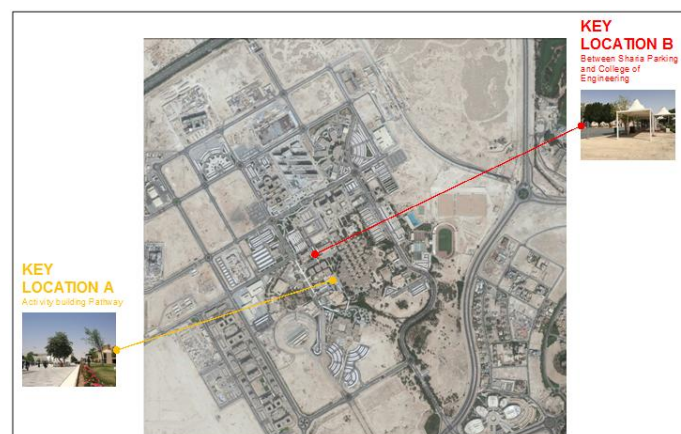


Fig-18: Key locations selected for direct impressionistic observations

The two selected key locations are indicated in the survey questionnaire results as one of the least and the most utilized shading device locations. The source of this information is gained from the user's response to the photo dialogue presented in the questionnaire sheet

(see appendix B). The first location (A) is one of the least utilized shading device location, which is found within Female Activity building pathway. Whereas the second location (B) is the most utilized location of shading devices found between Sharia Parking and

College of Engineering, illustrated by Figure 22 below. The two key locations are subjected to systematic observations in order to justify the effectiveness of the shading devices. The observation is followed by a brief

remark or commentary on each key location with reference to the pattern flow of users and design parameters of the shading devices.

Records of the Observations

Table-4: Records of the Direct Impressionistic Observations




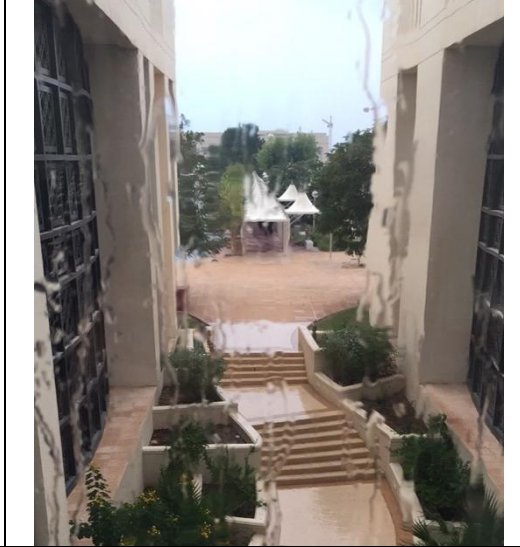
	Key Location (A): Activity Building Pathway	Key Location (B): Between Sharia Parking and College of Engineering
DAY/DATE	Wednesday, December 28, 2016	Wednesday, December 28, 2016
TIMING	1:00 – 3:00 PM	1:00 – 3:00 PM
IMAGE		
IMPORTANT REMARKS	<p>Students are walking beside the shaded areas, but not under the shading devices. This pattern of movement proves that the walking experience is unaffected by the existence of shading devices. The shortest path to the activity building's main entrance is a straight line parallel to the lining of the shading device, limiting the usage of the pathway.</p> <p>The shading device is non-continuous, irregular, and has wide spacing between the repetitive elements. The area of the overhang is not wide enough to project full shade on the ground.</p>	<p>The pathway is active during the rush hours in the campus as most of the students, faculty, and staff member are using the location for connection from the main Sharia parking to the rest of the nearby campus buildings and facilities. The pathway's narrow design directs people's flow to walk underneath the line as a directing strategy of walkability.</p> <p>The design of shading device is continuous, regular, and has no spacing between the umbrellas. In addition, it is located next to a wall and surrounded by dense vegetation to increase its effectiveness.</p>
DAY/DATE	Wednesday, November 23, 2016	Wednesday, November 23, 2016
TIMING	2:00 - 4:00 PM	2:00 - 4:00 PM

IMAGE		
IMPORTANT REMARKS	During a rainy day, the effectiveness of the shading devices is still doubtful as the devices are not protecting the underneath ground from the rain, except for the limited area of the shading overhang.	The pathway is efficient as students and users would find it providing a good shelter against rain, reducing the feeling of discomfort and help getting users to the parking area with less confusion.

Concluding Remark

Both key locations are providing dynamic scenes to analyze user's flow and response to the existence of shading devices. The first key location (A) is poor, insufficient and ineffective due to the design parameters of the shading device and placement in the center of an open plaza. Its most positive feature would be giving the campus an element of urban design by cutting the rigidity of the empty space it occupies. While key location (B) is proper, efficient and placed in the right position for the right reason. The external shading influencers such as the existence of a wall, mutual shading from nearby building and dense vegetation around the pathway improves the overall effectiveness of the shading device.

It is important to note that the orientation of both pathways is directed toward the north-west, which is the direction of the prevailing winds in Qatar. This fact might enhance the user's thermal comfort in terms of encouraging wind flow. However, the purpose of shading devices is to manage solar radiation and decrease the effect of discomfort caused by direct sun

rays and heat. Thus, full shade is required rather than the limited shade provided by the current shading devices. Full shade is achieved via dense urban environment, shielding by horizontal shading device, or directing pathways to be mutually shaded by buildings or other barriers. In extreme cases, a controlled environment is proposed as a conditioned space to avoid excessive sun radiation and heat.

Conclusion and Discussion

The final question of the survey questionnaire developed for this research study, that is generally aiming at assessing the effectiveness of the current solar management techniques in Qatar University campus based on user's satisfaction, requires for respondent's personal reflection. Thus, suggestions are obtained as ways to improve the effectiveness of the shading devices in the outdoor spaces of Qatar University campus. The following table summarizes the findings that are found to be thoughtful, supportive by design suggestions and indicate a perception of dissatisfaction with the overall effectiveness of shading devices.

Table-5: Respondent Comments as a conclusion to the research

#	Respondent Comments
1	"manage the shading devices to shade more areas and on one line not like we have on the campus."
2	"make it colored and surround it with activities."
3	"Creating large and wide shades."
4	"To improve the design and orientation of the shading devices."
5	"Make it more decorative and attractive, so people can get attracted and recognize their main purpose."
6	"Put more shading devices."
7	"When I walk under it somehow the sun leaks through in big amounts and I think it's because of the position and the amount of shading material."
8	"Shadings are mostly designed in a way that a very limited area is actually protected from the sun , in addition the shading material is pulled upwards from the sides and as a result it becomes very inefficient, in contrast if it was tilted downward, it would do a better shading specially in the midday times during summer."
9	"Changing the design and the orientation of the shade devices between the different buildings in the campus because they are not working the function very well neither shading nor defining the pathways."
10	"Increase more shading devices around areas close to buildings."
11	"Change the design"
12	"Increase the overhang of the shading devices."
13	"Place them properly."
14	"Provide Flat functional regular devices, not the ones that are provided now which does not provide any shade."
15	"Study the circulation routes."
16	"Yes, the weather is mostly hot and sunny that's why we need more shading devices that actually shades the area underneath it instead of just being built without any advantage!"
17	"The replication of the shading devices in a random manner that does not respect the solar orientation causes the shading device to be less effective."
18	"Honestly they look nice but are useless!"
19	"Studying the orientation of the shading device to provide more shade during daytime in the right direction. Also, these shading devices could be used for other purposes not only to define main walkways. For example, open spaces (plazas)."
20	"Increase their number depending on people flow and circulation."
21	"Add more."
22	"More focus on shading quality of devices used than on the form of the devices."
23	"Create better alternatives with closed canopies (similar to the one found at Qatar foundation outdoor ceremonial hall, with Islamic patterns) + Rethink the placement of them as some shading devices are not efficient at all (pathway between activities building and engineering building), it is just a waste of public space."
24	"Ac shading devices."
25	"To be continued not segregated. Or to be linked with natural shading elements to beautify it."
26	"The use of darker color. Light color allow the radiation to penetrate. (Keeping the same material)."
27	"Increase the devices to more areas."
28	"The shadings are not well designed they are just a view."
29	"The spacing between the shading devices should be reduced."
30	"We need a drop off for all the colleges."
31	"Air condition"
32	"Use pergolas with vegetation instead of plastic."
33	"Redesign the walking areas to limit the number of shading devices (keep a nice looking campus)."
34	"More shading in path."
35	"Placement and orientation."
36	"Study the Most using paths before creating and locating the shading devices."
37	"Change the whole designs of shading devices."

ACKNOWLEDGMENTS

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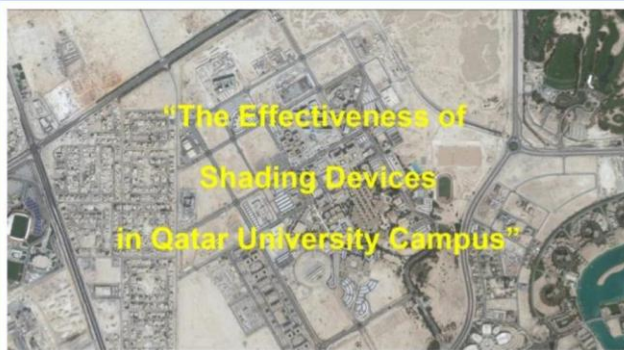
Brisbane), UAE (Canadian University of Dubai) and Qatar (Qatar University). He has been teaching Art History, History of Architecture, Project Management, Urban Design, Architecture Design and Interior Design. His areas of interest include Vernacular Architecture, Architecture and Urban Sociology, Project management, Art History. Member of the Board of Architects in Italy and Australia, he has 20 years professional experience, split between design management, project management and supervision roles, with some highly respected companies, 6 years of which were in Italy, 10 years in Australia, and 4 years in Middle East.

The authors would like to acknowledge the support of Qatar University for creating an environment that encourages academic research and unlocks the creative potential of budding researchers.

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Qatar University | College of Engineering
Department of Architecture and Urban Planning
Masters of Urban Planning and Design
MUPD 655- City & Regional Planning in Hot Arid Zones
Fall 2016

"THE EFFECTIVENESS OF SHADING DEVICES WITHIN QATAR UNIVERSITY CAMPUS"

This online survey is designed as part of a graduate course for Masters program. The purpose is to investigate the effectiveness of shading devices as an outdoor solar management technique within the campus of Qatar University. The aim is to optimize the use of the current shading devices and relate their efficiency to user's satisfaction and thermal comfort. We recommend designing better systems to support walkability and improve the outdoor urban environment in the campus of Qatar University.

This survey will take (5-10) minutes of your time:

Gender:
81 out of 81 people answered this question

1	Female	46 / 90%
2	Male	5 / 10%

Nationality:
81 out of 81 people answered this question

1	Qatari	36 / 71%
2	Non-Qatari	15 / 29%

Occupation at Qatar University:
81 out of 81 people answered this question

1	Student	44 / 86%
2	Faculty	5 / 10%
3	Staff	2 / 4%

How do you arrive to the campus:
81 out of 81 people answered this question

1	Drop-off by family or driver	33 / 65%
2	I drive my car	16 / 31%
3	University bus system	2 / 4%
4	Other	0 / 0%

What is your level of agreement on this statement:
"I think the outdoor spaces in Qatar University Campus are enjoyable"
81 out of 81 people answered this question

1	2	3	4	5
Average: 3.24				
Slightly Agree		Moderately Agree		Highly Agree

