



Structural Layout as a Crucial Factor Towards Campus Sustainability

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ABSTRACT

This research aims to examine the role of campus structure in achieving a sustainable environment. The study was conducted on the main campus of Baghdad University- Iraq, as a case study. In order to fulfil its practical parts, the research adopted a mix of quantitative and qualitative methods including questionnaire, in-depth interviews and observations as data collection techniques. Findings included some urban design characteristics as key indicators of this impact such as directness, permeability, traffic speed, compactness, campus size and car parks. Through its conclusions, the study contributes to address issues related to campus sustainability in Iraq and elsewhere in the world.

Keywords: Sustainable; campus; structure; layout; planning

1. INTRODUCTION

University campus is defined as an institutional space designed to be used for education and residence of college students; where it includes buildings and other physical elements existing in the associated area. Typically, universities possess residential, institutional, health care and recreational spaces (Chan, Coupland, Gagesch, Mulé, & Runyan, 2009). University campuses are characterized by a mixture of uses that allow students to move through these areas at different times and for different reasons providing vitality and positive economic outcomes (Jacobs, 1961).

Campus is similar to a city but of a smaller scale. This is because universities function like independent municipalities, where they have their own governance structure, accommodate a residential population, maintain streets and buildings, and support safety issues. Hence, a campus can be deemed as a city, which consists of elements that are highly interdependent (Abd-Razak, Utaberta, & Handryant, 2012; Nichols, 1990). Therefore, it could be helpful when a university's built form and design are discussed in a broader context to the city design where related issues are addressed on the campus design and planning (Chan et al., 2009).

Due to their indispensable role in developing a society, governments and other authorities give greater attention related to sustainability issue in university campuses. The history of sustainability efforts in higher education that began in the 1990s is considered relatively new. As universities are places of innovation and learning, a university campus is the ideal location to adopt concepts of urban sustainability at a smaller scale (Beringer, Wright, & Malone, 2008). Thus, sustainable development has become an increasingly important issue for universities around the world.

Campus development would be sustainable when it pursues improving life quality and meeting users' needs without negatively affecting the needs of future generations taking into consideration a balanced attention to its design aspects environmentally, socially and economically (Sohif et al., 2009). This study focuses on the sustainability of Iraqi university campuses that need to adopt the sustainable development strategies. This is to reduce the negative effects on the environment and to create a better quality of life and learning process for current and future generations of campus users.

planning and design can influence a campus physical character and determine whether it has a sustainable environment that cannot occur without paying enough attention to the detailed campus planning and design Chan et al. (2009). In this respect, the campus of 21st century was described by New Urbanism as following: "The campus of the 21st century will distinguish itself by demonstrating how the built environment can fit appropriately with the climate, the landscape, and the culture of the region" (Irvin, 2007). Abd-Razak et al. (2012) suggested that numerous physical aspects determine a number of indicators for sustainable physical planning on campus. Those indicators depend on several characteristics of physical campus character such as, structural layout, accessibility, circulation, building design, landscape and surrounding, transport and movement as well as safety and lighting. According to Beyaztas (2012), three of the campus physical characteristics affect campus sustainability performance, namely: density, residential character, and population. Not only that, but urban form properties are also relating to achieving key sustainable qualities of human settlements such as diversity, efficiency, resilience, permeability, legibility and intensity (Osmond (2008). Therefore, physical character could be a crucial factor for the campuses to be more sustainable environments.

As universities have a role in backing, learning and progress of societies, creating sustainable campuses has become a vital requirement to promote this role. Thus, university as an essential organization, its campus design cannot ignore sustainability issues in order to conduct its function positively. For this reason, sustainability of university campuses has recently become a global issue (Alshuwaikhat & Abubakar, 2008).

Many studies look at the campus structural layout as an influential factor on numerous issues of sustainability. This is because campus planning is related to aspects such as human, culture, history, and climate and so on. It was established that built form can influence human behaviour and hence the way by which it is being used. The layout concerns the arrangement of buildings and spaces, which in turn, determines aspects directly related to sustainability

such as compactness, accessibility and legibility. Plan arrangement of a built environment affects built form properties and uses (Ferriter, 2008; Jabareen, 2006b; Jenks & Jones, 2010; Oktay, 2004). This applies to many campus layout and planning features including compactness, paths organization and accessibility that influence pedestrian-oriented dimensions such as walkability, air pollution and safety (Sisson, McClain, & Tudor-Locke, 2008).

As the creation of sustainable campuses has become a necessary need for all universities in the 21st century, the need for an objective understanding on how to support campuses sustainability through their physical structures has emerged as an urgent matter. Therefore, this study attempts to answer the question: why is a campus structure important to support sustainability?

1.1 Theories of Campus Structure

Structural layout of a campus is one of the principal components that influences its physical character, hence, an important aspect to consider when designing or planning a sustainable university campus. The way the buildings are arranged and how paths are designed and linked are the main aspects that the campus planning might encompass (Dober, 1992; Ebrahimabadi, 2008; Eckert, 2012; Strange & Banning, 2001). In this regard, physical layout is divided into two: urban structure and urban grain. While the first is relating to the basic master plan of the built-up area that includes the configuration of paths and open spaces as well as how they are connected to each other, the latter deals with the arrangement of blocks and buildings in the area (Cowan & Rogers, 2005; DETR & CABE, 2000). According to Bentley, Alcock, Murrain, McGlynn, and Smith (1985) urban layout is based on the “dots” and the “lines”, which encompasses any aspect concerning form, structure or recurring feature. These aspects are associated with planning qualities of campus environment, which are linked to the sustainability values.

This study, therefore, assumes that campus layout influences numerous aspects of sustainability in Iraqi university campus. How spaces and places of a built area are connected to each other is determined by the configuration of the structural layout of this area. This is related to campus size and the distances between different parts of the campus, which affect the ease of pedestrian movement and vehicle circulation pattern. Permeability and the ease of way finding for the pedestrians are provided by layout configuration (Dempsey et al., 2010; ODPM, 2005). Dempsey et al. (2010) and Cowan (1997) suggested that the extent to which paths are connected to spaces has a great impact on how lively a place is. This can be regarded one of the factors influencing sustainability on campus due to its effect on the use of public spaces for social interaction and walkability of the campus environment. When campus layout encourages walking, it would decrease car reliance and, as a result, reduce air pollution and support social equity. Therefore, campus structure through its various planning features has been strongly advocated to be one of the major factors in creating sustainable universities.

2. MATERIAL AND METHODS

The main campus of Baghdad University - Iraq was chosen as a case study to conduct this research. This campus was selected because it is the oldest designed campus in the country representing the mother campus of all other campuses in Iraq. The other reason is the fact that the campus was designed by an internationally known architect, who claimed to address some climatic and cultural issues. His concept of the campus structure was to reflect the structures of traditional cities in the country through a non-geometric and compact layout.

This research adopts both quantitative and qualitative methods (mixed methodology) to conduct the field study. While a questionnaire survey was used as a quantitative technique, observation survey and in-depth interviews were used as qualitative techniques to gather the required data. The sample size of the questionnaire was 400 respondents including students, faculty and staff. This size of the sample is based on (De Vaus, 2001) calculation, in addition to previous studies such as (Saadatian, Sopian, & Salleh, 2013).

Field Observation was done during a five-day visit to the case study campus. It included assessing the different aspects of physical character of the campus such as paths network, buildings and space configuration as well as the public transport routes. Users' behaviors and activities in the outdoor environment were also observed. The observation employed two techniques: recording notes and taking photos. In- depth interviews were conducted using a sample size of 28 respondents based on (Walker, 1985). A triangulation method between data from different sources was used in order to establish reliable and valid conclusions.

For data analysis, logistic regression analysis, and descriptive statistics such as percentages and frequencies were used to analyze the data gathered quantitatively using the SPSS software. On the other hand, content analysis was used to analyze qualitative data gathered by observations, interviews and secondary sources.

3. RESULTS AND DISCUSSION

Two aspects of sustainability claimed to be affected by campus layout, namely the access to facilities and services as well as quality of air are addressed in this research.

3.1 Access to Facilities and Services

Accessibility is a design quality associated with social sustainability because of its relation to the ability to easily reaching services and goods as well as doing activities. Accessibility on campus is concerned with the ease to get to various destinations in the campus including facilities and services, academic, residential as well as recreational areas. It is directly affected by the structural layout of the campus. According to Eckert (2012), the easy access to

facilities and other destinations is an essential sustainability factor for campuses because it leads to the concern about campus spaces used by the pedestrians.

It therefore depends on the extent to which the campus layout is compact and the way in which the important uses are located on the campus. Burton (2000) revealed that good access to facilities and services is one of the advantages of a compact layout. On the other hand, in order to create accessible campus, a university needs to pay enough attention to the campus linkages and the design of the walkways. Hence, accessibility is an important design characteristic that directly influences the pattern of life on campus such as promoting walkability.

In the field study, campus users through a questionnaire survey were asked whether they can access easily to the important destinations on the campus. Figure 1 summarizes the responses where the facilities area¹, nearest dining place and nearest shop recorded high percentages of the responses to have easy access at about 75%, 84% and 83%, respectively. These results refer to the locations of these activities, where facilities area is located in an approximately central point to all academic areas (See Figure1), while dining places and shops are being distributed within the academic areas (Observation survey 2014). This indicates that walking distance from most academic areas to these facilities is a key factor to get easy access.

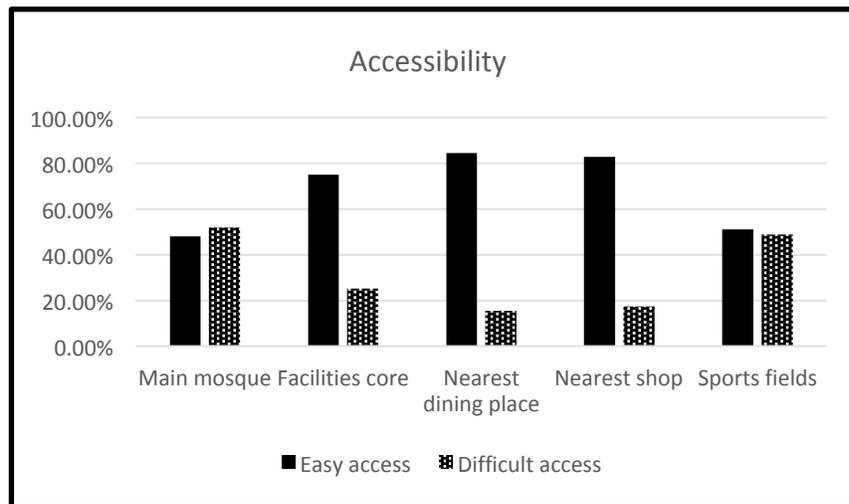


Figure 1: Perceived accessibility to important destinations on campus; source: fieldwork

However, responses of difficult access to the main mosque was recorded a high percentage by 52% of the respondents. This could be attributed to the location of the mosque. In addition to its location being far away from many academic clusters (about 1000 meters), the main ring road with high-speed traffic also separates the mosque from a majority of the academic areas (Field Observation, 2014). Therefore, students need to cross a busy road (once

¹ The term "Facilities area" in this study refers to the central area of the case study campus that includes several

or twice) in order to reach the mosque (See figure 2). Hence, the issue of safety from accidents arise as another key factor in the accessibility matter, as highlighted by the respondents who were interviewed (interview survey, 2014). Given the campus main mosque's importance to the Muslim communities, it should be located within easy and safe distance for the pedestrians from all academic and residential buildings. Its location should be integrating with the other major facilities such as student center and the library.

In order to investigate how campus layout elements, affect accessibility, a logistic regression analysis was conducted, where several variables related to the campus layout were entered into the regression model. Two destinations were chosen to be examined in this model as the most important for campus users, namely facilities area and the main mosque (Table 1).

Table 1: The impact of campus structure features on the accessibility on campus

Layout features	Access to facilities area		Access to main mosque	
	Coefficient	Sig.	Coefficient	Sig.
Distances between campus areas	.134	.50	-.102	.575
Campus size (Area)	.224	.32	-.847	.000***
Directness of pedestrian movement	.685	.00	.599	.002**
permeability of routes	-.278	.08	-.168	.229
The integration of pedestrian network	.180	.29	-.024	.872
Clustering and grouping	-.338	.03	-.118	.394
Traffic speed	-.412	.01	-.311	.028**
Efficiency of public transport	.244	.12	-.205	.111

* Statistically significant at 10% level

** Statistically significant at 5% level

*** Statistically significant at 1% level

Source: Fieldwork

Results of the regression analysis shows that creating direct ways (i.e. shortcuts) to the key destinations emerged as having significant impacts on the access to both facilities area and the main mosque, as they recorded (99% and 95%) confidence levels respectively. These results indicate the necessity of providing direct circulation to achieve a good access for pedestrian on campus. Respondents suggested that the possibility of pedestrian movement through buildings provides good shortcuts and direct ways to various destinations. (In-depth interview 2014). Designing for direct access on campus, particularly for pedestrian would enhance walkability as it makes users' movement easier that in turn, encourages them to walk.

According to Ross (2009), establishing direct ways for pedestrians is a key indicator for good accessibility. This is because the direct movement plays a role in reducing walking distance to a destination. Emphasizing the desired lines through providing convenient and well connected routes is a crucial factor in creating direct ways for

people's movement (M. Carmona, 2010). Therefore, the important destinations on campus need a direct linking to all the campus areas in order for them to be more accessible.

Table 1 also shows that traffic speed was reported a 95% confidence level with the access to both the main mosque and facilities area. These results make traffic speed emerges as having a significant relationship with the both destinations. This finding suggests the importance of safety issues in supporting campus accessibility. Several respondents mentioned that the fast-moving vehicles in the ring street act as an obstruction against reaching the mosque easily (In-depth interview, 2014). This indicates that traffic speed has the ability to affect pedestrians' movement and accessibility on campus. Traffic speed can be calmed through some planning and design features such as creating narrower streets and the use of on-street car parking (Cooper & Partners, 2000; Litman, 2014). As the fear from accidents can limit the easy access to some destinations, traffic speed on campus should be addressed for better safety and then better accessibility. Campus designers need to consider this aspect in schemes

Permeability of the layout gained 90% confidence level in the regression model, as another significant variable for access to facilities area (Table 1). This finding implies that providing multiple choices of routes is a crucial factor for better accessibility on campus. According to Hillier (1996), the degree of layout permeability allows the built form to control accessibility and pedestrians' movement. The layout of the studied campus allows an extent of permeability through providing more than one way to a specific destination. The way in which buildings are configured also contributed to this setting, where the movement through buildings provide alternatives for pedestrians to pass. Moreover, the organic nature of the pedestrian network allows more permeability and vitality in the walkway system (field survey, 2014). The interviewed people indicated this feature, where they can often find alternative ways to get to their goals, which gives easier access to facilities (In-depth interview, 2014). These findings disclosed that a permeable campus structure allows better pedestrian's access making the environment more sustainable.

Clustering and grouping of buildings recorded a confidence level of 95% with the access to the central facilities area in Table 1 that puts it as a significant factor in creating easier access to this area on the campus. Numerous studies such as Jabareen (2006a); Tsai (2004) and Bramley, Brown, Dempsey, Power, and Watkins (2010) emphasized compact building organization, as a substantial factor for urban sustainability. According to Burton (2000), compact layout provides better access to facilities and services. This also applies to campuses according to Abd-Razak et al. (2012) and Hashimshony and Haina (2006). It is true to say that, this feature would be strongly effective particularly in arid hot-dry atmosphere that characterizes the climate in Iraq and most of the Middle East countries. The observation survey distinguished a clustered building layout, where the campus buildings are arranged in the form of several groups including facilities area and academic areas (Figure 2).

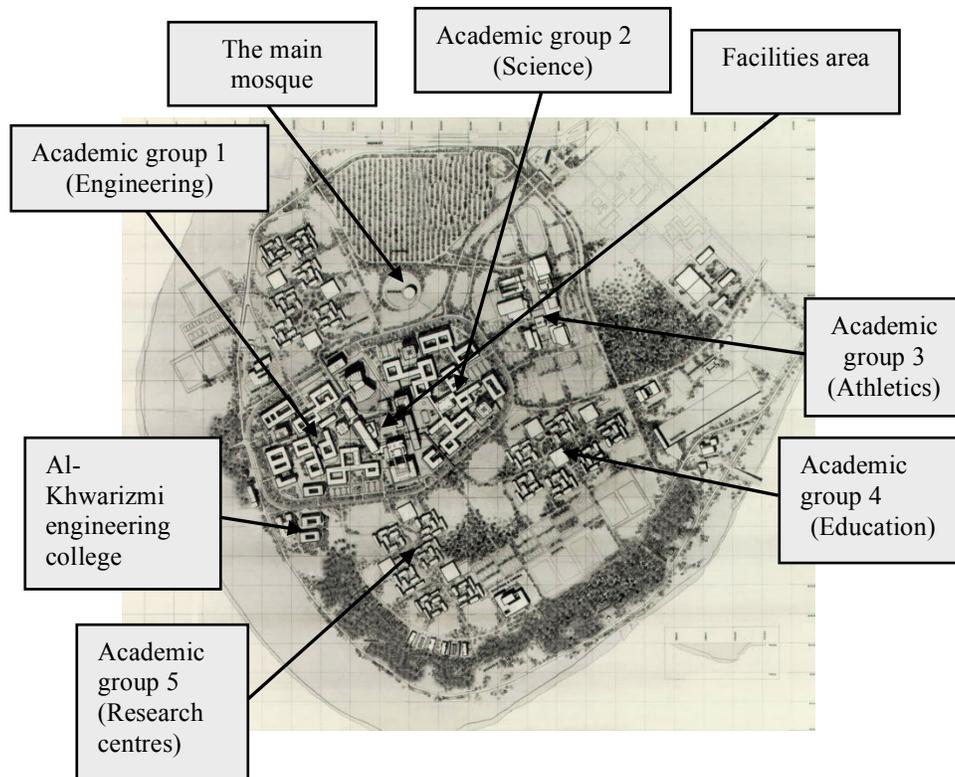


Figure 2: Campus building structure; source: campus design document 'Baghdad University- Preliminary design', 1967

This configuration allowed buildings to be in close proximity to each other and combined together through open spaces in the form of courtyards that serve as effective linkages between the buildings. The buildings within each group are also linked together at the first floors by some bridges (See Figure 3). This setting provides direct ways and shortcuts to pass through the buildings whether in the ground or first floor. Pedestrians use these shortcuts to access to various destinations directly and comfortably, as they are often shaded and visually interesting (Field observation 2014). This, in turn, supports pedestrian movement and accessibility on the campus, where the interviewees expressed their satisfaction with this configuration in terms of providing them with a good access. (Interview survey, 2014).

The compact configuration of campus layout particularly in the academic areas contributes to other sustainability features such as a sense of enclosure created in the formed courtyards and other spaces between buildings. It also enhances a thermal comfort in the open spaces between buildings. Indoor thermal comfort is also enhanced as a result of the compact grouping that minimizes the exposure of the buildings' external surfaces to the elements decreasing heat transfer between inside and outside. In short, a compact structural layout needs to be adopted by Iraqi campuses due to its role in enhancing the accessibility and other sustainability features.



Figure 3: Directness: shortcuts through the ground floor whilst maintaining linkages on the first floor enhance accessibility; source: Field observation

Campus size also gained a high significance level equals to 99% for the access to the main mosque. Campus size should be appropriate with both campus population and the amount of building, where such a balance can influence building density on campus represented by floor area ratio (FAR)². This ratio should be about 1:1 for university campuses (Master-Plan-Report, 2008). However, a lower density could affect distances between different campus areas, which in turn influences the accessibility of various destinations on campus. In other words, students and other users would have easy access by an appropriate campus size, where distances between different parts on campus would be shorter. This, in return, can promote campus walkability, where the interviewees indicated that shorter distances within built up areas encourage them to walk.

Higher density on campus can also enhance vitality and social interaction (DETR & CABE, 2000; Hashimshony & Haina, 2006). In contrast, the wide area of a campus with long distances between buildings affect accessibility and decrease the sense of safety (Abd-Razak et al., 2012). It can be concluded that the ease of pedestrian's movement has the potential to make a campus more walkable representing a principal factor of campus sustainability. Thus, the access to facilities and services as well as other destinations on campus is relating to campus planning including the compact configuration of buildings as well as campus size (area). It also

² Floor area ratio (FAR): Total floor area per square foot of land (Owens, 2005)

encompasses path system characteristics such as directness and permeability. Traffic speed was also differentiated as one of the significant factors that influence campus accessibility. These features, therefore, act as major components of a sustainable campus structure. This refers to the role of accessibility in supporting campus sustainability aspects such as social equity and interactions between people, walkability as well as the provision of human needs.

3.2 Air Quality

Air quality is a prerequisite to the creation of a healthy environment on campus. It is related to the environmental and social sustainability of a campus. Reducing the use of motorized vehicles within a campus is strongly associated with the environmental sustainability. According to Masnavi (2007), the harmful emissions released by motorized vehicles is a direct reason for air pollution and energy consumption. This affects the human health in addition to its environmental and economic harms. The results of the questionnaire survey showed that the majority (80%) of campus users never or rarely use their private cars to travel to their various destination in the campus, as shown in Figure 4. This result indicates that campus planning plays a role in reducing car reliance on the campus. A logistic regression model was conducted in order to establish how campus layout affects the frequency of use of motorized vehicle that in turn influence the local air quality. Table 2 shows the result of the regression analysis, where two layout features, namely the distances between uses and the grouping of buildings emerged as significant variables in the regression model.

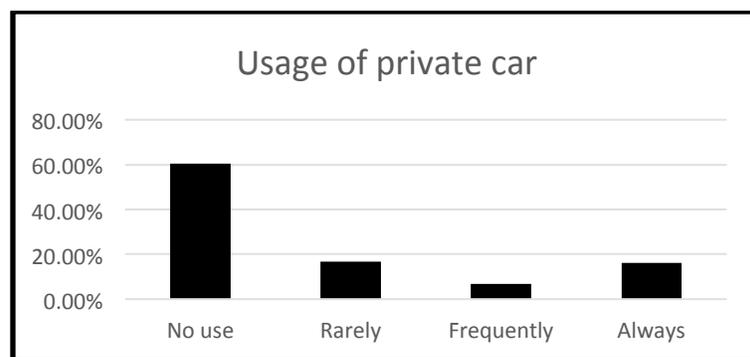


Figure 4: Frequency of use of private car on campus; source: fieldwork

Table 2: The impact of campus layout features on the use of private vehicle

Usage of private car		
Layout features	coefficient	Sig.
Distances between campus areas	-.691	.002***
Building density	-.088	.729
permeability of routes	-.165	.316
The integration of routs network clustering and grouping	-.090	.633
Traffic speed	-.486	.006***
Efficiency of public transportation	-.019	.918
Through traffic	.269	.117
parking for disabled	-.122	.416
Availability of parking	-.019	.929
Quality of car parking	-.559	.012**
Location of bus stop	-.257	.116
	.850	.012**

* Statistically significant at 10% level

** Statistically significant at 5% level

*** Statistically significant at 1% level

Source: Fieldwork

These features are related to how buildings are configured, combined and located in the campus and express the extent of the compactness the structure. Masnavi (2007) revealed that the distribution of facilities and land uses have an impact on the use of private vehicles. This quality directly affects walkability on campus, where the compact structure encourages people to walk instead of driving. This leads to the reduction of exhaust emissions that pollute the local air. The interviewed users mentioned that the short distances and the compact grouping of buildings encourage them to walk within the campus (In-depth interview, 2014). According to Masnavi (2007), distance travelled to a destination is a key factor to determine the energy used and air pollution produced. The above findings and arguments indicate that a structural configuration on campus is crucial in determining the use of private motorized vehicles and the extent to which the campus provides for a healthy environment.

According to the results of regression model in Table 2, the availability of car parks was reported as having a statistical association at a confidence level of 99%, demonstrating this variable as an influential factor for the use of private vehicles in the campus. This aspect has sparked different opinions. Whilst some argued that availability of

car parks is convenient to car users, others, however, think that the limited provision of car parks could decrease car reliance and, as a result, make people go towards their destinations on foot. Dober (1992) considered parking spots on campus as one of 'place making' elements of the campus. Car parks need to be sufficient, convenient (located nearby), attractive and safe, which are often preferred by campus users (Eckert (2012) and M. Carmona, Heath, T., Oc, T. and Tiesdell, S. (2003). Nevertheless, it was argued by Dober (1992) that the parking lots on campus should be pushed to campus edges. This strategy would make people cross the required distances by walking to their destinations. In this way, the use of motorized vehicles within campus areas would decrease leading to less pollutant emissions. This remains appropriate as long as the traveled distance does not exceed 10-minute walking. On the other hand, keeping the standards of car park provision at the minimum could lead to reducing their negative effects (M. Carmona, 2010).

Through the field observation, it was noticed that car parking lots on the studied campus are distributed along a loop street that serves the majority of campus areas. Although, this layout is efficient in preventing the penetration of car through the academic areas or facilities area, car parks are widespread in the campus particularly, near the buildings. Though this setting provides accessible and abundant car parking places, it is deemed unsustainable in terms of encouraging the use of private vehicle, increasing the consumption of land and creating undesirable views. Instead, in order to allow for a more sustainable provision of car parks, large surface parking lots should be replaced by structure-type parking, which is suitable to be located at a central location in the campus (Irvin, 2007).

Returning to table 2, location of bus stops recorded a confidence level of 95% that put it within the significant variables affecting the use of private vehicle. This feature is related to the use of public transport that represents a sustainable mode for people to move within campus areas. M. Carmona, Heath, T., Oc, T. and Tiesdell, S. (2003) considered the access to public transport as one of the sustainable urban design principles. The more efficient the public transport, the less dependence on private vehicles on campus would be achieved. According to Davies (2007), bus stop should be located within 10- minute walking or 800 meters distance, while the working-group (2004) determined this distance to be 600 meters walking. This can encourage campus users to use public transport over private cars, which contributes to less pollutant emissions to the air.

Through the field study, 70.5% of the respondents considered their access to the nearest bus stop as easy. Some interviewed users described a period of 5-minute walking to the bus stop from academic department as a comfortable distance. This directly affected the use of the public buses by campus users, where about 58% of the respondents use the public buses on campus (always or frequently), as shown in Figure 5. This denotes that the bus service is used by the greatest percentage of campus users, which indicates a positive aspect of this service towards more sustainability.

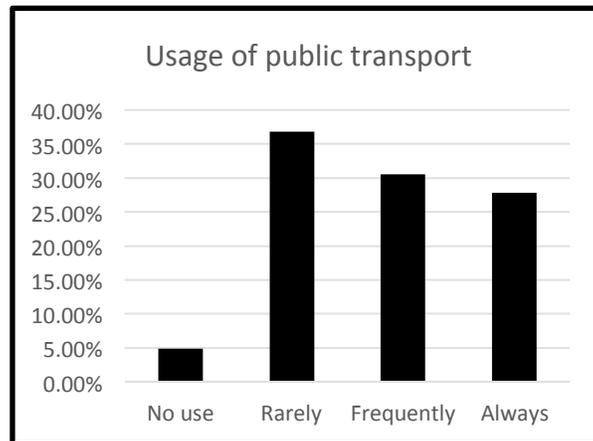


Figure 5: Frequency of use of public transport in campus; source: fieldwork

However, a low rate of service frequency was noticed, which affects the use of the public transport that discourage some people using the public bus (Field Observation, 2014). This can be attributed to the inefficient management of the trip schedules. The number and locations of bus stops should be considered in the campus layout planning to create a healthy campus. To conclude, in order to reduce the use of private vehicles on campus, enough attention needs to be paid to several important features including bus stops in terms their locations and accessibility. This also include the creation of a compact configuration of campus structure as well as the provision of car parking. These features have the potential to affect the use of private vehicle that, in turn, leads to a less pollution, less energy consumption and a better quality of life.

4. CONCLUSION

This paper is to establish how the structural layout affects sustainability of university campuses. The study found that campus structure has a considerable contribution to make a campus more sustainable socially, environmentally and even economically. Using quantitative and qualitative methods, the study examined the physical components of campus structure against two aspects of urban sustainability. The first is related to social sustainability, namely the accessibility on campus, while the other is associated with both environmental and social sustainability and indirectly the economic sustainability, namely in the use of private cars as a function of air quality. Findings proved that planning features have the ability to support directly campus walkability and the ease of pedestrians' movement, which are very important components of campus sustainability.

The accessibility on campus emphasized the access from academic buildings to two of the key destinations on campus, namely facilities area and the main mosque, Results indicates that the layout setting of the studied campus provides a good extent of accessibility in general. However, safety and distance issues represents obstacles to provide easy access.

Through logistic regression models, the access to facilities area and the main mosque were examined against the campus layout aspects. Five aspects of campus structure emerged as having the most impact on the access to those destinations. Campus size and buildings' groupings appeared as significant variables for the access to facilities area. Whilst the former is associated with building density, the latter is related to the configuration of campus buildings and the way they are related to each other. Those two aspects determine whether campus layout is compact, which is an important factor for campus sustainability through influencing the movement patterns on campus. It also contributes to the ease of movement through providing shaded ways and a sense of enclosure (by buildings) for the pedestrians that also support accessibility. Thus, the compact structure is seen as a key feature for campus sustainability.

The existence of direct ways showed a significant influence on the access to the both destinations. Similarly, layout permeability also emerged as a significant variable for the access to facilities area, which is related to whether the campus paths networks provide multiple choices for the pedestrians and vehicles. The study found that the more direct the paths with more choices given for pedestrians' movement, the more accessible is the destinations within the campus. Findings also included that the pattern of building configuration plays a role in providing direct and permeable ways for pedestrians in the campus. In other words, the possibility of walking through buildings can provide good shortcuts that, in turn, serve as direct ways and provide multiple choices of routes for pedestrian movement.

The ease of crossing streets (in terms of traffic speed) is another significant feature contributing to the access to both facilities area and the mosque. This feature is related to the conflict points between vehicles and pedestrian movement, where traffic speed is a crucial factor in crossing the street easily and safely towards a destination. Therefore, the potential of campus layout to provide traffic calming measures is a key factor to create an accessible and sustainable campus.

Findings indicated that campus layout has an impact on private vehicle use contributing to create a healthier environment. Distances between campus areas and the groupings and clustering of buildings should be given a greater attention because they can lead to a compact layout. This could enhance a campus walkability that leads to a lesser use of motorized vehicles and then less air pollution. Another layout aspect, namely the location of bus stops emerged as a significant variable of the private car use on campus. Universities campuses should locate the bus stops in appropriate proximity points (within 600-800 meters) from important buildings due to their impact on the efficiency of public transport of the campus that, in turn, leads to decreased private car dependence. This would improve the local air quality.

Campus layout has an effect on more than one direction of campus sustainability. The first is the environmental direction, where it can encourage the sustainable modes of transport such as walking and public bus rather than private cars. This decreases the harmful emissions to the air, contributing to less greenhouse effects and minimize resource and energy depletion. Secondly, a lesser amount of transport emissions enhances human health and

improves the quality of life, which is related to social sustainability. The third direction is the economic aspect, where the more the use of public transport or walking, the less cost will be paid for traveling and health care.

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