Alternatives to sustainable transportation system in campus of The University of Baghdad

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Abstract. Research developed system of transportation at the University of Baghdad campus, based on indicators, although main goal for a clean environment with economical returns, but it can be beneficial for environmental sustainability as well as economic profits. Consequently, there is a need to submit new proposals on sustainable transportation based on policies determined by research objective in reducing number of parking spaces and increasing clean transportation options in walking, biking and an electric train. Research problem is environmental pollution due to transportation system within the University of Baghdad and lack of equity in distribution of parking lots, and thus a difference in arrival time to buildings. First, it was touched upon sustainable transportation policies and features in high-frequency places of movement such as universities, and then analyzing general plan of the University of Baghdad and methods of movement and parking that were previously designed to determine whether it meets requirements of building users. Then assessing quality environment of master plan by modelling to find out the relationship between required road area and number parking lots, by a set of variables have an effect on realization sustainable transportation policies, as well as to estimate needs in relation to parking lots. The results concluded that the parking lot distribution is neither environmentally sustainable nor social justification, given clear difference in duration of arrival for students and staff on foot from parking to building and lack of equity in distribution. However, a group over 23% can contribute to sustainable transportation by walking. Therefore, research recommends preparing and implementing design for transportation programs, parking lots and biking paths according to the effects of variables in statistical model to reduce problems of planning, environmental, social and economic on campus.

Keywords: Baghdad, campus, sustainable, car sharing, policies

1. Introduction

Setting sustainable transportation standards in perceived high frequency density areas like universities, city centers and recreational areas is critical to planning sustainable transportation. However, addition of new buildings on campus of University of Baghdad is rarely accompanied by construction of parking spaces suitable for new building or suitable for number of users in it, space available for parking in general depends on number of current and future users, especially various jobs and students with requirements of new colleges or departments. University's parking site is also associated with land use, number of visitors and infrastructure for general scheme. Moreover, location of parking lots is often not dependent on environmental aspect. [1].

Therefore, hypothesis of research is the adoption of sustainable transportation policies that affect distribution of car parks in achieving an economic return, as well as achieving sustainable environmental development through sustainable forms of transportation, including clean transportation and encouraging walking and cycling. Part of this hypothesis is to reduce parking spaces by reducing private cars and making university environmentally, economically and socially viable. Therefore, this paper begins with a review of sustainable transportation policies and then an analysis of transportation on campus of the University of Baghdad. Research relied on collect data through interviews, viewing and direct survey. Data were also from master plan of campus and offices in university. Then analyzing these data by statistic model and
evaluating them to reach the best future plan for transportation union on campus that can be generalized to other universities and achieve spatial relevance and equity in reaching buildings.

2. Sustainable transportation concept
Sustainable transportation is associated with concept of clean transportation, and concept of sustainable transport refers to any mode or choice of transportation with little impact on environment, and consists of most important policies including adoption of non-mechanical transport, walking, cycling, green vehicles and the method of participation in vehicles. All of this leads to urban transportation systems to efficient and economical fuel consumption, the preservation of open space and the support of a clean and healthy life. Concept of “sustainable transport” originally comes from vocabulary of Sustainability. It was used to describe transport systems that correspond to broader sustainability issues. Sustained transport is defined by the transport ministers of the European Union as access, communication, and rapprochement between needs of individuals, powers and society with less cost and safety and speed that is compatible with body health and environment that gives equality between next generations. It is cost-effective, socially just, and support effective economic competition. It is also decreasing emissions and waste in land, air and water. Sustainable transportation uses renewable or green resources [2].

Sustainable transportation systems and policies are positive tools for economic, environmental and social sustainability. It also provides social and economic connectivity that gives easy, safe, comfortable and affordable access through efficient mobility. The main advantage of this efficiency is that these systems have potential to achieve a balanced environment, socially and economically integrated. For example, the environmental impacts of transportation systems ranged from 20% to 25% by using electricity or by reducing carbon dioxide emissions [3]. Sustainable transportation systems have proven to be faster than polluting energy industry, because traditional transportation is the main source of urban air pollution. But there must be social costs for transportation such as road accidents, air pollution, lack of sporting activity, waste of time and high fuel prices [4]. Economically, traffic congestion leads to an increase in economic expenses, waste of time and delay in arrival to public utility. Given real goal is access to education, workplace, services, and entertainment, traditional transportation strategies, especially for cars, do not deal with the wider detrimental effect of transportation. In contrast, sustainable transportation aims to improve accessibility while trying to reduce negative impacts on the environment and society at same time. Consequently, societies that promote transport sustainability become part of a broader policy to develop sustainable and vibrant city [5].

3. Sustainable Transportation Policies
The sustainable transport policies and programs are among most important influences on sustainability of city as a major issue linked to movement of people, goods and land use planning. Hence legislative laws that contain guiding principles of sustainability, the impact of climate and climate change on transport planning. City laws have identified need to strengthen relationship between sustainability with transportation policies for conservation and environmental protection, for example policies to reduce excursions, redesign places and shapes of parking lots, take into account the preservation of natural elements, increase pedestrian paths, bike lanes and parking location, and move towards increasing the aesthetic value of this tracks and finally reduced fuel consumption [6]. Sustainable transportation policies that can be applied on campus are:

3.1. Car Sharing Program
It is a model that includes renting vehicles for more than nine passengers for specific periods of time (office hours, for example) that aims to reduce total number of vehicles and thus reduce need for more parking spaces. It differs from traditional leasing, as program or institution administrator differs from original car
This program is part of a larger co-transportation model. Participation is permitted at other times and for other purposes or contributes to access to public transportation systems. This institution is either a company or a public or cooperative agency. [7].

3.2. Parking Cash-out Program
The advantages aspect of this program is that the employer offers affiliates the option to accept cash payment with tax instead of providing free parking or a subsidized price on site of company or institution. This program encourages employees not to drive their own cars which cause environmental problems such as traffic congestion and emitting gases into the air. Given this option, most employees will take this amount and choose to program, walk, or bike on the daily business trip. With the benefit of greater benefits, more social equity and a cleaner environment, there is flexibility in reducing area of parking [8].

3.3. Parking price adjustments
Low-cost or free parking does not encourage using public transportation or environmentally friendly alternative options. It makes users pay to use parking lots. So it has to be shown to people that there are no free parking spaces. Although it can be gave free of charge, it is at expense of environmental and city pollution and taxes. Main objective of this program is to put high price of parking for associates and visitors, especially on the high-density campus [9].

3.4. Park & Ride Lot
Providing car and bike parking with good services must be parking for public transport cars that help residents to reach their destination after leaving their cars and moving to buses or public transportation systems, or walking rest of their way. As the car is left in service parking lot for a fee that person pays to return to his car. These squares are located in the vicinity of universities. [10].

These facilities allow passengers to avoid driving fatigue along crowded roads and the difficulty of finding rare and costly parking spaces in areas with high time density. This program reduces congestion by using the public transportation system in these areas. [11].

3.5. Biking Promotion Programs/Facilities and Safety
It is encourage promotion of biking rather than driving. This program provides features such as presence of short and Long-term bicycle parking, and armrests in covered bicycle parking [12]. Other services include bike sharing. Institution offers bikes used by employees to perform tasks within the institution or university issues related to work. Traffic safety and accident prevention are guaranteed.

3.6. Public transport
Public transport is the transportation of people via mass transportation for use by all residents and visitors, and is managed according to a schedule published in the means of communication on fixed roads and imposes wages for each trip. The most important examples are buses, trams, metro trains and underground metro, and enters with river transport. With fixed repeat services running (such as "every ten minutes"). With it, served walking paths to reach the stations [14].

These policies are easy to apply and suitable for implementation in Iraq, especially universities, due to appropriateness of the university’s location in Baghdad and its capabilities to implement these programs.

4. Case Study
The Case study is the campus of Baghdad University in Jadriyah, which has an area of 326 hectares, in which departments, colleges, administrative and service buildings are distributed. The car parks in master plan are distributed around buildings on both sides of the annual road, but these parking spaces do not cover
entire site and do not represent design of Walter Gropius except for certain sites. These yards were not developed or improved in particular as planning solutions aimed at urban sustainability under a very large number of users with simple attempts such as encouraging walking, cultivating large areas of shade trees, and build car parks around the buildings; however, these proposals need to be more appropriate, environmentally, economically and socially [Field survey].

4.1. Problem of research

Main problem related with movement of students, staff and employees on university campus and a significant increase in morning crowds and the end of the afternoon work as driver is forced to stand for more than an hour with these cars speaking of environmental pollution due to distribution of parking lots on main road exclusively in site. To determine problem, researchers distributed a questionnaire to students, professors, and visitors, and data was collected through direct interviews. First problem was congestion at entrance to Baghdad University during peak hours. Second problem is within walking distance, especially students in university housing, that are far from bus ring road or from car parks. These distances are relatively long due to high or low temperatures. Third problem is an imbalance in parking distribution, with walking distance reaching more than 250 meters [Data via AutoCAD basic master plan]. Finally, the parking area is 5% of the site area, and is not distributed according to the absorption of neighboring buildings or user density. As for buses, they cause major air pollution, with possible accidents due to the speed of cars that exceed 60 km / hour. [Field survey].

4.2. Sustainable transport program at campus

Most important on-site features on campus are that there are enough spaces to use as parking lots or new paths for bicycles, walking and planting new trees between buildings. The good use of these spaces guarantees social equity in reaching place of study or work. There are green spaces with large areas. In addition to possibility of controlling transportation system through road in finding parking lots according to actual need. And promoting it among students, employees, and even visitors through media and external screens, especially in the presence of expertise in sustainable transport planning and clean electric transport technology.

4.3. Master plan

The area of campus site is 325 hectares. Buildings occupy 32.8% of site, while roads and parking lots are 10.4% (Table 1), master plan of the campus has been prepared in advance, but implementation was over time periods of up to 30 years and the implementation of parking lots did not coincide with the buildings for financial reasons, which led to pressure on parking more than others.

| Details              | Area m²   | %     |
|----------------------|-----------|-------|
| 1 Buildings          | 1071636   | 32.8  |
| 2 Parking            | 169620    | 5.3   |
| 3 Roads              | 165230    | 5.1   |
| 4 Parks, squares and walkway | 662744 | 20.1  |
| 5 public services    | 72210     | 2.3   |
| 6 open spaces        | 1118560   | 34.4  |
| 7 Total              | 3260000   | 100   |

Source: Researcher based on master plan
The field survey included distributing the questionnaire to a sample of users in first working hours and at end of official working hours, in addition to data collected about each building, including number of employees. This data included the number of cars in parking serving buildings. Distance between building and parking with traditional vehicle and bike surveys.

5. Results

Depending on number of employees in each building, the buildings are divided into ten categories, obtained from official departments and capacity of parking for a whole week as highest vehicle number was approved because it represents users with visitors. The table shows the building categories, according to number of students, professors, and other users. finally, duration of accessibility.

| Table 2: Categories of buildings and access duration |
|-----------------------------------------------|
| No. | Category / number of users | Buildings no. | 5min. | 10 min. | 11+ |
|-----|--------------------------|---------------|-------|---------|-----|
| 1   | 1-99                     | 14            | 45    | 32      | 21  |
| 2   | 100-199                  | 8             | 34    | 41      | 22  |
| 3   | 200-299                  | 9             | 32    | 36      | 26  |
| 4   | 300-399                  | 6             | 37    | 42      | 21  |
| 5   | 400-499                  | 5             | 20    | 43      | 38  |
| 6   | 500-599                  | 6             | 18    | 37      | 40  |
| 7   | 600-699                  | 5             | 18    | 42      | 41  |
| 8   | 700-799                  | 3             | 11    | 26      | 61  |
| 9   | 800-899                  | 2             | 13    | 25      | 58  |
| 10  | 900+                     | 3             | 12    | 26      | 59  |

Source: Researcher based on survey
As for transportation surveys, it includes the highest number of vehicles and their ownership on campus, and is considered most important indicator of environmental pollution; and determines number of required parking lots. The results, as in (Table 3), represent requirements of distribution, absorption and distribution of parking lots so that it does not exceed six minutes on average for duration of arrival from garage to the building on foot and determines suitability of sustainable transportation like bike and walking on campus in order to achieve research hypothesis.

Table 3: Transport surveys according to number, ownership and capacity of cars

| Category number | Vehicle category/Passenger | Number of vehicles | Required space/m² | Average: passengers per vehicle | Ownership of the vehicle | No. of private vehicles |
|-----------------|---------------------------|-------------------|-------------------|-------------------------------|--------------------------|-------------------------|
| First           | 1-4                       | 1959              | 49100             | 2                             | 37%                      | 1452                    |
| Second          | 5-11                      | 468               | 13750             | 9                             | 2%                       | 19                      |
| Third           | 12-27                     | 29                | 974               | 22                            | -                        | 0                       |
| Fourth          | 40-45                     | 11                | 866               | 43                            | -                        | -                       |
| Total           |                           | 2467              | 64690             |                               |                          | 1471                    |

Source: Researchers based on field survey

Table 4: commuting cost per vehicle category/$

| No. | Vehicle category/Passenger | No. of car passengers / vehicle | Average total passengers | Average cost person / day/$ | Total cost /$(22 days) |
|-----|----------------------------|-------------------------------|--------------------------|-----------------------------|------------------------|
| 1   | 1-4                        | 1959                          | 2                        | 3                           | 258720                 |
| 2   | 5-11                       | 917                           | 9                        | 2                           | 362736                 |
| 3   | 12-27                      | 29                            | 22                       | 1.5                         | 37422                  |
| 4   | 40-45                      | 18                            | 43                       | 1                           | 17820                  |
| Total|                           | 2923                          | 14123                    |                             | 676698                 |

Source: Researcher based on field survey

5.1. Implement sustainable transport program
Implementing sustainable transportation programs to achieve university's objectives in sustainable development, reducing cost of trip and reducing transportation problems in pollution and traffic accidents. This is accomplished by reducing arrival time (six minutes) for walking on campus; decreasing parking spaces to suit assimilation buildings and number of their users only, redistributing land uses around buildings, improving pedestrian paths, adding bicycle paths and its parks with green belt around buildings (Figure 6); and promotion of planning solutions that enhance walking and cycling and the pursuit of concept of social justice at duration of arrival, cost and road safety, as well as implementation of green transport system.

1) Working days only, and holidays are not counted
5.2. Statistical model
The model was built to determine the effect of independent variables on road spaces and the area of parking spaces and its number as an approved variable, with a set of independent factors affecting adopted variable. The linear regression model was adopted, which assumes that there is a linear relationship between independent variables and dependent variable that ultimately achieves research hypothesis and adopts equation with future prediction.

Model Inputs
From concepts of sustainable transport, Selection of variables relied on their impact on alternatives to sustainable transport policies as a main objective of research, which was derived from field survey. Independent variables are defined as follows:
1: Students (under graduate): X1
2: Postgraduate Students: X2
3: Staff: X3
4: Employees: X4
5: Vehicles entering campus: X5
6: Bicycles: X6
7: Accessibility duration: X7
8: commuting cost: X8
9: Trees (Provide shadows on walking): X9
Y: parking area (That is redistributed as needed)

The model was built to predict the number of parking lots, which aims to:
Improve campus environment by organizing transportation network and providing more mobility options such as walking, biking, and electric buses to reduce the negative impact on the environment [16], inputs were for three time periods and fourth for future forecasting.
Table 5: Model input

| Year | X(1) | X(2) | X(3) | X(4) | X(5) | X(6) | X(7) | X(8) | X(9) |
|------|------|------|------|------|------|------|------|------|------|
| 2017 | 13903| 613  | 1967 | 2189 | 2397 | 0    | 15   | 77   | 17960|
| 2018 | 13929| 706  | 1981 | 2204 | 2411 | 0    | 14   | 74   | 18210|
| 2019 | 13936| 749  | 2000 | 2226 | 2455 | 0    | 12   | 72   | 18665|
| 2020 | 14000| 800  | 2000 | 2500 | 2000 | 1000 | 6    | 52   | 20000|

Source: researcher based on data of construction and projects department in Baghdad university

Table 6: Outputs of model

| b0   | b1   | b2   | b3   | b4   | b5   | b6   | b7   | b8   | b9   |
|------|------|------|------|------|------|------|------|------|------|
| 49.816| 0.516| 0.516| 0.516| 0.516| 2.34 | -0.031| -0.0011| 0.70 | -0.13 |

The inverse relationship appeared to have little effect due to its shortage or absence, and that increasing it in future turns it into a positive relationship.

Form of model:
Data for independent variables was entered using SPSS. And the adoption of multiple linear regression program and equation is as:

\[ Y = b_0 + b_1x_1 + b_2x_2 + \cdots + b_9x_9 \]

\[ b_0 = 49.816 \]
\[ b_1, b_2, b_3, b_4 = -0.516 \]
\[ b_5 = 2.34 \]
\[ b_6 = -0.031 \]
\[ b_7 = -0.0011 \]
\[ b_8 = 0.70 \]
\[ b_9 = -0.13 \]
\[ Y_e(2019) = 11414 \text{ (vehicle)} \]
\[ Y_f(2020) = 10118 \]

Model testing
From model outputs: value of r2 shows that 95% of independent variables have a significant effect, and thus corroborate hypothesis.

6. Discussion
The parking space in the primary design is 169620 m², with a percentage of 5.3% of campus, which accommodates more than 100% of vehicles that enter campus daily. Although all car parks are horizontal. Largest number of vehicles is four-passenger capacity and constitutes 80%. While proportion of nine-passenger vehicles is 18.6%, 1.1% capacity 21 persons and 0.41% for 45 persons. All parking required 64577 m², accounting for 77% of current parking, it is divided into all vehicle categories. Extra parking space can be used for open spaces and bicycle parking. The number of private cars is 1468, and it requires an area of 36,700 square meters, which is actual area on campus spread over colleges, which represents no more than 22% of parking space and serves 16% of users.
There is no social justification in distribution of parking lots, due to clear difference in length of arrival on foot from the closest parking lot to building by students, staff, and professors. The percentage of time to reach more than 11 minutes was 41%, 6-10 minutes to 36%, while comfortable ratio of less than a minute was only 23%. The bike utilization rate is (zero)%.

This culture must be spread, despite being restricted to males in Iraqi society, and economical use of bikes is second only to walking.

In economic terms, total cost for all daily trips exceeds 676 thousand dollars per month, including collection of parking lots, which constitute 33%, At a monthly rate 56 dollars per person. As for cost of constructing roads and parking lots for required number of cars in campus, total cost of new parking and roads covers 10.4%, in local cost, it reached $ 5 million. These areas or costs did not achieve any policy of sustainable transportation or feasibility due to large cost when compared to its revenue.

As for walking, their percentage of internal departments and university housing is 23%, including residents of near university, which is a good ratio that can contribute to achieving desired goal. Although arrival time of more than 11 minutes from closest parking lot on foot to building is uncomfortable, 45% of these hiking trails are covered with big trees providing shadows for the duration of the walk.

7. Conclusion

The research is an application of a concept of sustainable transportation and its programs in areas with a time density and a perceived high frequency density and choice of a case study represented in the campus of the University of Baghdad. Among results, this application achieves an environment that improves through multiplicity of transportation, bicycle and walking options with spatial and temporal suitability of parking lots, as well as results encourage improve environmental economy, and most important search results are:

7.1. Effect of independent variables

Results of the analysis were in line with future expectations, as they achieved environmental and economic integration as well as social benefits. The nine independent variables in research gave support to the research hypothesis and an explanation appropriate to the future plan in operating sustainable transport models and their durability for coming years.

7.2. Importance of variables impact

Statistical model is appropriate for Explanation of sustainable transportation methods and programs. Using these modeling results to make planning decisions that preserve green areas and do not interfere with sustainable transportation programs. For example, positive effect of users’ numbers on all classes, vehicles’ numbers on campus, cost of commuting. Negative impact of both few numbers of biking, high arrival time and lack of green spaces compared to parking space. The results provided data and weights on factors that make transportation options more sustainable, which can motivate residents themselves to achieve targets that are lost when landscape recedes. As well as awareness that helps motivate investors to invest in implementing sustainable transportation.

Model determines number and area of parking spaces and redistribution. And negative impact of some variables necessitates achieving a spatial balance, so it is suggested to reduce horizontal parking lots and implement multi-stores car parks to save space in favor of the increase in landscapes. All of this would contribute to preserving the land and the environment.

Given that the estimated coefficients for the independent variables were consistent with expected values, the research has a set of issues that are worth studying:

a) R2 is relatively low due to the small sample size.

b) Increase public awareness of sustainable transport and face difficulties associated with psychological factors such as societal inconvenience in female cycling.
8. Recommendation
The research recommendations are based on results of the statistical analysis as follows:
1) Design of master plan for internal transport system must be based on sustainable transportation programs to reduce negative impacts on environment, economic feasibility and social equity.
2) Emphasis on developing clean transportation, such as an electric train.
3) Designing two tracks for electric trains, and determining the duration of the train movement, with running four trains in track to confirmation its presence every four minutes.
4) The two tracks serve main center according to frequency of visitors who are often heading to center, and permanent employees according to workplace.
5) Preparing a detailed design for a sector of 7 hectares (2.5% of the site), which depends on its requirements on statistical model outputs, as it contains buildings, parking lots, bicycle sites, electric train tracks, car paths, walkways, and bicycles (Figure 4).
6) Cultivating green spaces with trees of various heights suitable for environmental orientation, and cultivating green line for transportation system with a special quality of trees (Figure 5).
7) Utilizing several levels of transportation patterns in intersections between modes (A tunnel or/and a bridge) to maintain smooth traffic and arrival time. With adoption of modern technology in designing bicycle sites with installation of bicycle movement screen at university (Figure 5).
8) Designing integrated vertical car parks to serve all categories of users and those with special needs and determining their appropriate locations to serve buildings in a balanced way.

Figure 3: Plan of two paths of electric train. Source: researcher
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Figure 4: Design of typical unit of paths: biking, walking, train and cars with building

Figure 5: Electric train (right), design of bike Shed (left)
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