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Assessment of the impacts of harsh weather on use of sustainable transport options: The case of Dubai

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ABSTRACT

Purpose: This research aims to examine the impacts of harsh environments (hot and humid weather) on use of sustainable transport modes (Specifically Mass Transit) when users have a choice and reasonable access to such modes. The research also aims to determine the influence of relevant socio-economic characteristics on users' mode selections given the harsh weather.

Design/Methodology/Approach: A random representative sample of Dubai transport system users were polled to determine their mode selections when a choice actually exists. Reasoning for stated choices and other socio-economic factors were solicited. Suitable statistical hypotheses were tested to assure the validity and significant of the findings.

Findings: Although majority of users stated that harsh weather is an influencing factor in their mode choice, the difference in the responses was not statistically significant to support a





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conclusion that the harsh weather of Dubai is mode selection determining factor. Users were also not sensitive to modest changes in fuel prices. Sizable increases (3- and 4-fold) in fuel prices were found to likely induce a change in attitude and perhaps cause a modal shift in favour of the more sustainable modes of metro and transit bus.

Originality/Value: The study presents answers on the likely contribution of harsh weather to the low percentage of commuter trips use mass transit in Dubai. The study also exposes the likely influence of increase in fuel prices on commuter's mode choices. The findings have significant implications to transport polices and funding of different modes in the area or areas with similar weather and socio-economic characteristics.

Keywords: transport; harsh weather; transit use; mode choice; fuel prices.

INTRODUCTION

Transportation has a major role in the development of any economy. It links people, goods and services throughout society. Transportation infrastructures such as roads and metro systems receive huge investments from authorities towards their development. Transportation can be categorised into two sectors, private and public transportation. Private transportation has a wide variety of modes, but the most significant mode is the use of personal vehicles. The use of personal vehicle has many advantages such as privacy for the commuters and freedom of movement at their convenience (Lang-8, 2010). However the disadvantages are that more cars are introduced to the streets everyday therefore exhausting capacities of roads and causing huge investments towards increasing them. Also a disadvantage is that private commuters face stress due to traffic congestion.

Public transportation or mass transit systems such as the bus or metro on the other hand have numerous advantages such as being cheaper to the users of personal vehicles and having less of an impact on the environment but most importantly reduce congestion on roads and therefore reducing users stress, but they take privacy and freedom of movement away from users. However the main benefit of using mass transit systems to personal vehicles is that mass transit users do not spend money on buying a vehicle, getting insurance for that vehicle, servicing the vehicle, spend money and time finding a parking space and last but not least the paying for fuel.

CONGESTION ON DUBAI ROADS

Dubai has invested heavily in the development of both private and public transportation systems. Road transportation investments include expanding major road capacities and building bridges to reduce





waiting time on traffic lights and roundabouts. Public transportation has seen a major development in recent years, such as the completion of the Dubai Metro in 2009 and most recently the introduction of the Dubai Tram in 2014. Another older mass transit system is the Dubai bus network. The Dubai metro system consists of two lines, Red and Green. The Red line has 29 stations on 52.1 km line length. The Green Line has 20 stations on 22.5 km line length. There are plans to increase both metro lines in anticipation to the Expo 2020 event that Dubai will host in the year 2020 (Shahbandari, 2015).

Problem statement

High temperatures and humidity levels are severe in the summer and the use of a personal car is often preferable by commuters, because with public transportation it is required to walk in the harsh environment from ones residence to a metro or bus station. Another cause is the social barrier of the use of public transportation. A portion of residents might think that using public transportation might affect their social standing or people's perception of their wealth, because public transportation is affordable to almost all the population. Also the public transportation systems might not be accessible to people in remote places or that they are not aware about the presence of such facilities near them. Major congestion occurs daily among users of routes connecting Dubai and the Northern Emirates, a main issue affecting transition from private to public transportation of these users is the lack of a suitable public transportation system. Comparing Dubai to other cities from around the world which also have the similar public transportation systems, one difference is very significant to others which is the harsh environment Dubai experiences in the summer season. Harsh environments include temperatures reaching as high as 50°C, sandstorms and extreme humidity levels. Public transportation users would have great difficulty moving from one place to another in these harsh conditions, also private transportation users who would want to use public transportation would find it hard to change their mode of transportation.

STUDY SIGNIFICANCE AND OBJECTIVES

This research aims to examine the impacts of harsh environments (hot and humid weather) on use of sustainable transport modes (Specifically Mass Transit) when users have a choice and reasonable access to such modes. The research also aims to determine the influence of relevant socio-economic characteristics on users' mode selections given the harsh weather. The significance is that impact of the harsh environment: high temperature, and high levels of humidity on road users has not been investigated into and an evaluation is needed for

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the many drivers that are facing in their transition to public transportation. The main target of this project is to assess if the harsh weather is an issue or factor stopping the transition of personal vehicle users into using public transportation. Also this report will study the impact of increasing fuel prices on the switch of road users and public transportation. This report analyses the results obtained in the survey some hypotheses will be tested against the results.

Objectives

This study aims to:

1. assess how the harsh weather environment impacts commuting on public transportation for people who live in Dubai and have access to public transportation within a reasonable walking distance and
2. analyse effect of increasing fuel prices on public transportation usage.

LITERATURE REVIEW

Khattak and Palma examined traveller behaviour under normal and unexpected travel conditions in real-life situations. The study reported that travel decisions are influenced by weather more than other variables such as route and mode (Khattak and Palma, 1997). Stover and McCormack studied the effects of weather on bus ridership in Pierce County, Washington, for the years 2006–2008. Four weather variables were considered: wind, temperature, rain and snow. High winds negatively affected ridership in winter, spring and autumn. Cold temperatures led to decreases in ridership in winter. Rain negatively affected ridership in all four seasons, and snow was associated with lower ridership in autumn and winter. These results suggest that adverse weather conditions can have a negative effect on transit ridership (Stover and McCormack, 2012). Saneinejad et al. investigated the impact of severe cold weather on active modes of transportation in the city of Toronto in Canada. The study showed that young individuals who walk and bike are more negatively affected by cold temperature than older age groups. Also the use of the bicycle is sensitive to temperatures only in conditions below 15°C, while walking is only sensitive to temperature below 5°C and to a smaller extent than bike trips. Wind speed negatively influences cyclists about twice as much as pedestrians. Also, female's tendency to bike is about 1.5 times more negatively affected by cold temperatures than males (Saneinejad et al., 2012).

Flynn et al. quantified the impact of weather conditions on individual decisions to commute to work by bicycle in the northeastern state





of Vermont, USA. The study was conducted in an area with adverse winter conditions. The study reported that temperature, wind and snow conditions had significant and substantial independent effects on the odds of travel to work by bicycle among a diverse panel of adult bicycle commuters (Flynn et al., 2012).

Belwal and Belwal did a public needs assessment and an opinion survey in the Al-Batinah region of Oman of public transportation systems. Oman has very similar weather conditions to Dubai in the summer, where temperatures could reach 50°C and walking is not a preferable choice. The study found that public transportation systems in Oman are very minimal and do not match their demand. It also concluded that “marketing of public transport services is constrained by certain environmental issues, particularly the socio-cultural and physical environments”. Ultimately this article was a visibility study to assess the practicality of a new mass transit system. However this is different from the case in Dubai where there is a mass transit network of busses and metro and tram routes (Belwal and Belwal, 2010).

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METHODOLOGY

The scope of this study was to investigate personal vehicle user’s perception on the use of mass transit systems in harsh weather in the city of Dubai, to determine if it influences their decision on using their personal vehicle and also to determine if a fuel price increase would shift these individuals to use the bus or metro. Although Dubai is located in a metropolitan area that includes the city of Sharjah and Ajman where some people live in these cities but work in Dubai. The scope was concentrated towards the people living in Dubai, because public transportation is not available in a feasible condition between Dubai, Sharjah and Ajman, and because Dubai has a vast public transportation system in the city itself. To achieve the objectives of this study a survey was conducted and suitable statistical hypotheses were tested to assure the validity and significance of the findings.

Survey and sample size

The survey was presented to road commuters who have access to public transportation in Dubai but use personal vehicles. The survey was given out randomly to people in market places and it was not conducted in only one area but spread around all of Dubai which has a population of about 2,327,000. This is important because people who tend to visit a nearby shopping centre are most likely to live in a close by area and





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therefore the survey was given out in different places so that it would not be biased.

The number of surveys needed for the study was found to be 196 at least to get a good sample size of Dubai's population. This number was calculated using the population size of Dubai and with the confidence level of 95% and a confidence interval of 7% which is an interval to estimate a population parameter (Newsom, 2013). The number of surveys actually collected was 211. The survey contained multiple choice questions. Every effort was made to ensure the randomness of the selected subject.

Statistical hypotheses tested

From the survey, several factors such as the effect of harsh environment and fuel prices on road users would be examined. Relevant hypothesis were formulated to help achieve the objectives of the study and are summarised in Table 1.

Table 1 Summary table showing null hypotheses tested

<i>No.</i>	<i>Null Hypotheses</i>
1	The majority of people who live in Dubai and have access to public transportation but use their personal vehicles think that hot or humid weather is a reason for them to not use the bus or metro for their daily commutes.
2	The majority of people who live in Dubai and have access to public transportation but use their personal vehicles to commute to or from work would use the bus or metro station if it is within 2 min walking distance.
3	The majority of people who live in Dubai and have access to public transportation but use their personal vehicles to commute to or from work would use their personal vehicle to work if fuel prices would double.
4	The majority of people who live in Dubai and have access to public transportation but use their personal vehicles to commute to or from work would not use their personal vehicle to work if fuel prices would triple.
5	65% of people who live in Dubai and have access to public transportation but use their personal vehicles to commute to or from work would not use their personal vehicle to work if fuel prices would quadruple.

Profile of sample respondents

Out of 732 people surveyed 364 respondents lived in Dubai, and of the 364 people 211 had access to public transportation. Of the 211 people surveyed 110 were male and 101 were female. About 27% of the 211 people surveyed made more than 20,000 Dirhams a month which had the largest group followed by 19.9% who made between 10,000 and 15,000 Dirhams. The largest amount of people surveyed belonged to the 25–35 age group consisting of 45%. Of the 211 people surveyed 11 females refused to provide their age.





RESULTS AND DISCUSSION

Trends in analysis of harsh weather effect on mass transit use

Figures 1 and 2 show a breakdown of the reasons for not using public transport during both favourable (December) and harsh weather (July). Results show that in July and December, hot and humid weather was the main reason for road users to not use the bus or metro. Although hot and humid weather is not the case in December, road users thought that due to the hot and humid weather in the summer, it would affect their yearlong decision. More people believed that hot or humid weather was the main reason for them not to use the bus or metro in July than in December, about 39% of males and 52% of females thought it was the main reason in July however the percentage decreased when asked if it was an issue in December to 18% for males and 33% females. This shows that in cooler months less people thought it was a factor. More females than males thought that hot and humid weather was a factor.

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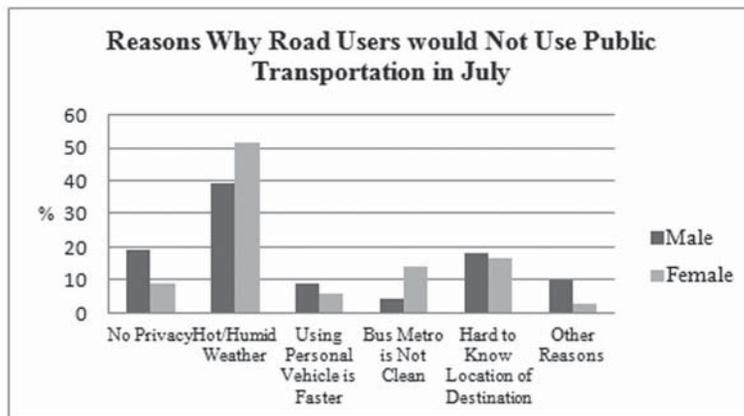


Figure 1 Reasons why road users would not use public transportation in July

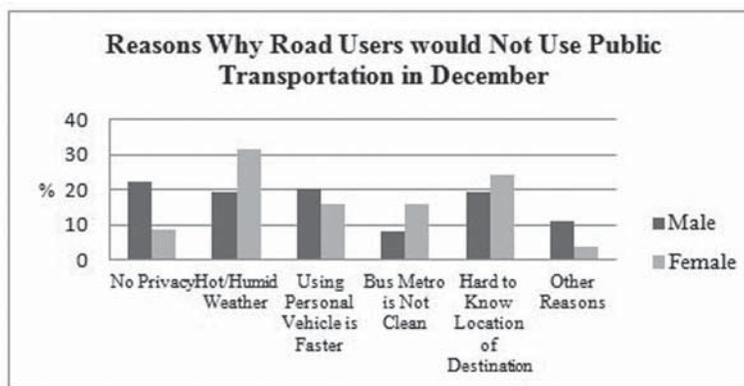


Figure 2 Reasons why road users would not use public transportation in December



Figures 3 and 4 show results on acceptable walking distances with based on level of heat and humidity (July versus December). For the month of July about 67% of males and 68% of females thought that the maximum walking distance in July was 5 min or less, comparing these values for the month of December the percentage falls to 39% males and 35% females. The intervals for 5 to 10 min and 10 to 15 min increased significantly for both males and females, this shows that people in general would prefer to walk further in the winter season than in the summer.

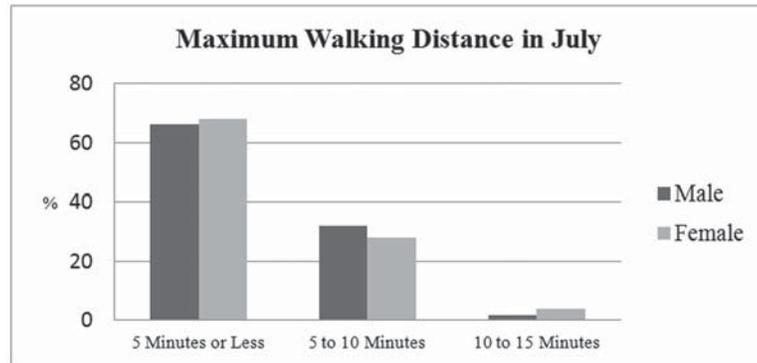


Figure 3 Maximum walking distance in July

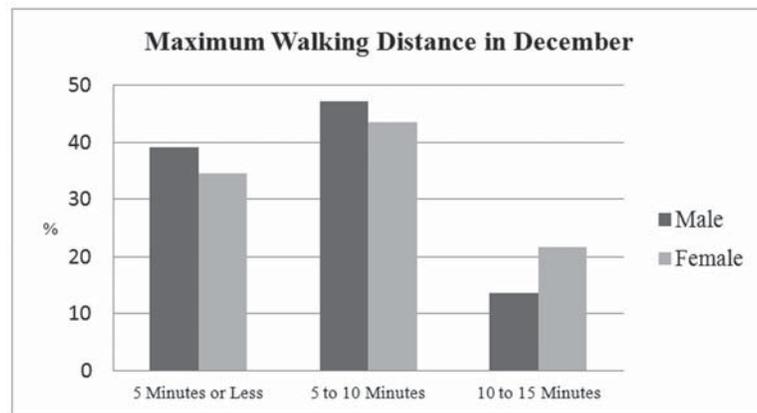


Figure 4 Maximum walking distance in December

Hypothesis test for effect of harsh weather on use of mass transport

To assess if hot or humid weather is a reason for them to not use the bus or metro for daily commutes and the following null hypothesis was tested: Null Hypothesis: The majority of people who live in Dubai and



have access to public transportation but use their personal vehicles think that hot or humid weather is a reason for them to not use the bus or metro for their daily commutes. Table 2 shows the number of people who answered yes and no to the question and their corresponding percentages were calculated.

Table 2 Correspondents response on the question if hot or humid weather is a reason for them not using the mass transit system

	<i>Count</i>	<i>%</i>
Yes	110	52.1327
No	101	47.8673
Total	211	100

The following equation was used to get the z score, p was used as the 0.521327 which is the proportion of the correspondents who chose yes. π is the null hypothesis value, which is 0.5 in this case because a majority is any value of 50% and more, and n is the number of correspondents which is 211.

$$z = \frac{p - \pi}{\sqrt{\pi(1 - \pi)/n}}$$

$$z = \frac{0.521327 - 0.50}{\sqrt{0.50(1 - 0.50)/211}}$$

$$z = 0.6196$$

The z value is compared to the critical z value obtained in the z -table which corresponds to the outer 5% of the sampling distribution, the critical value is always 1.65 for a one-tailed significance regardless of sample size. The value 0.6196 is less than 1.65, therefore null hypothesis is rejected. The above result shows that the majority of people who live in Dubai and have access to public transportation but choose to use their personal vehicle do not think that hot or humid weather is reason for them not to use the public transportation system. Several other hypotheses were tested using the above noted tests. Their results are in noted in Table 2.

Summary of null hypotheses results

Table 3 shows the results of all the null hypotheses tested in the study and their respective results.





Table 3 Null hypotheses results

<i>No.</i>	<i>Null Hypotheses</i>	<i>Result</i>
1	The majority of people who live in Dubai and have access to public transportation but use their personal vehicles think that hot or humid weather is a reason for them to not use the bus or metro for their daily commutes.	Rejected
2	The majority of people who live in Dubai and have access to public transportation but use their personal vehicles to commute to or from work would use the bus or metro station if it is within 2 min walking distance.	Rejected
3	The majority of people who live in Dubai and have access to public transportation but use their personal vehicles to commute to or from work would not use their personal vehicle to work if fuel prices would double.	Rejected
4	The majority of people who live in Dubai and have access to public transportation but use their personal vehicles to commute to or from work would not use their personal vehicle to work if fuel prices would triple.	Accepted
5	65% of people who live in Dubai and have access to public transportation but use their personal vehicles to commute to or from work would not use their personal vehicle to work if fuel prices would quadruple.	Accepted

Result limitations

This research had some limitations as discussed below:

1. Statistical tests could have been performed for each income level when testing the effect of increasing fuel prices but were not because it was not part of the study.
2. Questions about metro and bus service reliability could have been addressed but were not because it was not part of the study.
3. Multiple choice question could have been asked instead of yes/no question which would have given the people surveyed more options.
4. Fuel prices have changed since the month of November when the project was completed. Therefore the findings that are related to fuel price might change.

CONCLUSIONS AND RECOMMENDATIONS

This research examined the impacts of harsh environments (hot and humid weather) on use of sustainable transport modes (Specifically Mass Transit) when users have a choice and reasonable access to such modes.





The analysis concluded that there is a connection between harsh weather and public transportation usage for road users who have access to it but do not use it, however it showed that hot or humid weather is not a significant factor for the majority of road users in Dubai that have access to public transportation to not use it. The collected findings from the survey were analysed to determine the connection between a fuel price increase and a switch from personal vehicle usage to mass transit use. The survey had asked three different questions for three different fuel price increases, which have price increases of double (two fold), triple (three fold) and Quadruple (four fold). It showed that doubling the fuel prices will not shift the majority of road users to use the bus or metro, it would however shift road users with a monthly income of less than 5000 Dirhams to use public transportation. By increasing fuel prices by three times the current price, it would make the majority of road users use the bus or metro. It affects all income levels except for road users who make more than 20,000 Dirhams a month. By increasing fuel prices four times the current price it would cause 65% of road users to switch from using private vehicles to bus or metro.

It is recommended that all limitations noted earlier be addressed in similar future studies. Residents of neighbouring Emirates should also be included in future studies. There is anecdotal evidence that cultural factors are at play when selecting transit as a mode of travel. Future studies should explore such issues.

REFERENCES

- Belwal, R. and Belwal, S. (2010) 'Public transportation services in Oman: a study of public perceptions', *Journal of Public Transportation*, Vol. 13, No. 4, pp.1–21.
- Flynn, B.S., Dana, G.S., Sears, J. and Aultman-Hall, L. (2012) 'Weather factor impacts on commuting to work by bicycle', *Preventive Medicine*, Vol. 54, No. 2, pp.122–124.
- Khattak, J. and Palma, A.D. (1997) 'The impact of adverse weather conditions on the propensity to change travel decisions: a survey of Brussels commuters', *Transportation Research Part A: Policy and Practice*, Vol. 31, No. 3, pp.181–203.
- Lang-8 (2010, 14 March) *The Advantages and Disadvantages of Private Cars*, Available at: <http://lang-8.com/119590/journals/406575>.
- Newsom, J. (2013) 'Single-group statistical tests with a binary dependent variable', *Lecture notes from USP 634 Data Analysis: Spring 2013 Course*, Portland State University, Available at: http://www.upa.pdx.edu/IOA/newsom/da1/ho_z-test.pdf.
- Saneinejad, S., Roorda, M.J. and Kennedy C. (2012) 'Modeling the impact of weather conditions on active transportation travel behavior', *Transportation Research Part D: Transport and Environment*, Vol. 17, No. 2, pp.129–137.
- Shahbandari, S. (2015, 16 December) 'Dubai metro's route 2020 station revealed', *Gulf News*, Available at: <http://gulfnews.com/news/uae/transport/dubai-metro-s-route-2020-station-revealed-1.1638839>.
- Stover, V.W. and McCormack, E.D. (2012) 'The impact of weather on bus ridership in Pierce County, Washington', *Journal of Public Transportation*, Vol. 15, No. 1, pp.95–110.

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BIOGRAPHICAL NOTES

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