Enhancing the Use of Transit in Arid Regions: Case of Abu Dhabi

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ABSTRACT

Abu Dhabi, capital city of United Arab Emirates, is an emerging global city. As part of its identity, the city aims to provide world class facilities and service in the region, including a good network of public transportation. The city introduced bus service with future plans to add rail system to their network of public transit. Understanding the perception of current transit users can help provide service recommendation and help identify the trip characteristics, travel behavior and perceptions that can enhance current transit system and provide future recommendations to introduce effective rail network. This study uses the transit user stated preference survey to examine the trip characteristics; travel behavior; perception of quality of service, social network and personal characteristics of transit users of Abu Dhabi. The analysis of respondents provides insights for housing development, transit service enhancement and creating transit-oriented development within walkable distance of transit stops.

Keywords:
Stated Preference, public transportation, Abu Dhabi, walking to transit, transit oriented development

INTRODUCTION

Urban and transportation studies suggest that alternative modes of travel need to be incorporated to address the needs of the growing population in major cities across the world. Private automobile continues to be the primary mode of travel for majority of these urban residents and hence alternative modes of travel including mass public transportation is seen as a solution to
deal with the ill-effects of increased auto usage such as emissions, congestion, and individual’s physical and mental health (Ettema, 2016). Communities are being planned or being retrofitted to provide opportunities to use these alternative modes of travel for their daily trips, and reduce the use of automobile for reaching their destinations (Calimente, 2012). Similarly, Abu Dhabi, as an emerging global city hopes to provide its residents with all possible modes of transportation, including efficient public transportation.

Urban societies with alternative transportation network provides safe and efficient transport by mobilizing communities by easing traffic congestion while making travel cost effective. Public transit is one such alternative transportation service available for low-income and disadvantaged population (seniors, persons with disability, etc). Public transit systems in the US provides approximately 58 thousand million passenger miles (APTA, 2015), it has not been a popular choice for trips made in the GCC region. However, with the increase in both local and non-national population in the region, the GCC region is making conscience effort to introduce an efficient transit system. The United Arab Emirates, in line with major cities in the Gulf Cooperative Council (GCC) region, is taking initiatives to overcome the gaps in urban transportation infrastructure as reported by the World Bank (2009). Some measures taken include introduction of fleet of buses exclusively for women by the RTA in Dubai, while Sharjah and Abu Dhabi have introduced several new routes and buses to provide an efficient bus service.

To overcome the transportation gap, the Surface Transport Master Plan 2030 (STMP) for Abu Dhabi was drafted by the Abu Dhabi Department of Transportation in 2008. One of the objectives of the plan is to implement a sustainable transportation plan that is consistent with the urban and economic growth of the city (STMP, 2009). This plan aims to reduce the reliance on
automobile; improve the pedestrian environment; encourage Transit Oriented Development (TOD) and improve the safety and accessibility of the city.

However, little information is available about the patterns of transit use by individuals in City of Abu Dhabi. Who are using transit, and for what reason? What are the demographic and socio-economic characteristics of transit ridership and whom of these made the mode shifts to and away from transit? What are the factors influencing transit ridership in Abu Dhabi? Survey data (measurement of travel characteristics for transit ridership) is required to answer such important questions. The rate of urbanization in Abu Dhabi and the lack of research on this topic makes this study imperative and timely. Both urban planner (Urban Planning Council) and the transportation planners (Department of Municipal Affairs and Transportation) will benefit from understanding the transit user behavior and have important implications for the future of transit development in Abu Dhabi.

Therefore, the objective of this study is to examine the demographics of transit users; transit service quality; trip purposes and characteristics; and travel behavior that influences ridership in the mainland of city of Abu Dhabi. Through this we aim to answer the following questions: Is there a social exclusion of transit riders in Abu Dhabi? Does distance to public transit influence the frequency of use of public transit? Does having an accessible land use relate to individuals walking to transit? What impact does transit use have on current and future land uses and developments for the city of Abu Dhabi? To understand and answer these transit user behavior, we survey transit user in the mainland of city of Abu Dhabi. Bus service being the major public transit system in Abu Dhabi, this study will refer to the same as public transit in general.
The following section discusses the literature about historical development of Abu Dhabi and its current land use and transportation planning approaches. Following this literature assessing transit ridership in general and in the gulf region in particular is discussed. The study area characteristics and the survey instrument implementation is discussed in the methods section followed by description of data and its implications for transit service and ridership enhancement in the city of Abu Dhabi. Recommendation to improve the service quality and transit users experience is proposed to achieve the goal of efficient transit system in the region.

HISTORICAL DEVELOPMENT OF ABU DHABI

The urban development of Abu Dhabi city has been through six transformation phases which made the evolution of the city commensurate with its social and traditional history (Allawi, 2017). The six phases were (Fig 1):

A. Pearl Era (up to the 1930s): The emirates were as independent states during this period and pearl tradition was the main source of income for its residents (Allawi, 2017).

B. Unification Phase (1950s – 1972): This period experienced the discovery of oil in 1958 and the announcement of the United Arab Emirates in 1971 with Abu Dhabi as the capital. With the economic growth of Abu Dhabi, the city started to develop gradually. The plan of the city was established by Dr. Abdulrahman Makhlouf, and it consist of rectangular blocks that continued until these days as the make-up of the urban fabric of the city. Each block has a four to five story buildings surrounded by parking, with each neighborhood block consisting of one or two mosques to serve the population in that area. New roads were developed in the 1960s with the first paved roads being the Almaqtaa Bridge and the Airport road that connected the Qasr Al Hosn fort, the home and office of the ruler, with other secondary streets (Ghazal, 2013).
C. Formation Phase (1972 – 1991): After the union of the seven emirates, the city continued to develop its public and private sectors, and the road network expanded with the city to have better network connectivity. The City also saw an increase in immigrant population and the development of residential towers, villa communities and department stores, as an indoor public spaces, to avoid the extreme weather during summer (Allawi, 2017).

D. Constant Phase (1991 – 2003): High rise commercial and residential buildings (15 to 20 stories) were built in the downtown of Abu Dhabi Island (Al Markaziyah and Tourist Club districts area) which was the core of the city. Low rise buildings as well as villas were located in
the south-east of the city (Al Bateen and Al Manaseer district areas) which also housed the royal palaces and embassies (Allawi, 2017).

E. Instant Phase (2003 – 2008): During this period the city implemented multiple architectural projects that shaped the skyline of the city and its adjacent islands. In 2007 the Urban Planning Council (UPC) was established as another government authority beside Abu Dhabi Municipality. The UPC regulated the growth of the city through the Abu Dhabi Plan 2030, which continued till the economic crises in 2008 (UPC, 2007).

F. Diversification Phase (2008 – present): All through the economic crises, there were many diversification efforts in economy, culture, heritage, and urban planning. The use of technological advancement in urban planning and the concept of smart cities and smart solutions, helped not only Abu Dhabi but also other GCC cities create efficient infrastructure designs (Allawi, 2017).

One consistent feature of the city through these phases since the development of major roads are the development of super blocks in the city of Abu Dhabi. The urban super blocks, as determined from the major roads dissecting the developments, vary in sizes along the urban corridors of Abu Dhabi. These super blocks range from the size of 400m x 400m upto 500m x 1000m. High rise buildings, mostly used as commercial and residential units, adorn the edges, while the building typology and its use inside vary across the super blocks. Some blocks have residential villas that are two to three floors high (Fig. 2, A) while others have five to six floored apartment buildings with retail at the bottom (Fig 2, B).
The residential villas are used primarily by families with children while the apartment buildings host both families and bachelors’ groups, with retails services such as laundry, grocery, remittance office, coffee shops at the ground level. The type of housing (density) and the land use mix (diversity) of each block impacts the general accessibility to variety of services within the block including use of public transit. Hence the transit user perception and behavior can be influenced by the size and composition of land uses within each block, while the needs of these users can help determine the kind of development that can be proposed to enhance the use of transit in the city. Besides the density and diversity dimensions of the urban environment, studies have identified several determinants of transit ridership which needs to be acknowledged, even if not investigated as part of this study.

**TRANSIT RIDERSHIP AND ITS DETERMINANTS**

Public transportation typically serves individuals of the community (1) who either do not drive, like young, elderly or disabled; (2) people who do not own a car (children or low income people)
and (3) individuals who chose to use transit as their mode of travel either because of convenience or their personal choice. Irrespective of the purpose, it is proposed that the built environment around the station area should provide easy access to transit stops, minimizing the distance from stations to destinations. Accessibility to transit, hence, is an important determinant of use of transit for its users.

Research on accessibility to transit reports that the regional accessibility to transit stations has a positive correlation with transit usage. For instance, individuals who have good access to bus stations are more probable to use transit stations than other modes of travel (Arrington & Cervero, 2008). Accessibility, in general, is defined as the ease to reach destinations and land use activities for both individuals and group of people (Geurs & Wee 2004). Most measures of accessibility evaluate the time taken to reach specific destination or for specific purpose (Albacete, et al, 2015). Hence, as the time to reach a specific destination increases, the accessibility to that destination decreases. A study in San Jose, California reported that walking time to transit was inversely related to transit ridership. Their study reported that for every five-minute increase in walking time to transit, ridership frequency reduced by 5% for drivers and 25% for non-drivers (Hess, 2009).

Besides regional level indicators, local level indicators have been investigated for its influence on transit use, especially accessing transit by walk (Maghelal 2011; Maghelal and Capp 2011). Cervero and Kockelman (1997), in their seminal study, categorized these built-environmental in three dimensions of Design, Density and Diversity. Improving the design in an urban area such as shading devices and trees with seating along the pedestrian paths; increases the use of non-motorized modes like walking and biking. A mixed use development with pedestrian amenities in dense city center will encourage transit use than an auto-oriented suburb
Another study examined the relation between the mix of destinations in a built environment and the associated physical activity. It concluded that high physical activity can be achieved by walking to diverse destinations and hence proximity to and mix of destinations are positively associated to walking for transport (Lee and Moudon, 2006).

Although this study examines the access to transit, it does not analyze the built-environment and its influence on use of transit. It attempts to understand the transit users and their stated preference of the service quality, travel behavior and trip purposes of bus service in the city of Abu Dhabi. The proceeding section of literature briefs the current knowledge in this context.

**TRANSIT USER STATED PREFERENCE**

Several studies in the recent past, have investigated the transit user stated preference by surveying either individuals or households through online surveys, on-board surveys or field observations. Most of these surveys were conducted with the purpose of enhancing the transportation service, particularly targeting use of transit (Noland & Dipetrillo, 2015; Shaaban & Khalil, 2013) and for improved built-environmental setting to make communities suitable for non-motorized mode of travel.

Studies targeting the enhanced use of public transit have generally analyzed proximity to transit, origin-destination of trips; service quality and inputs, passenger preferences and behavior, and user demographics. For instance, Noland & Dipetrillo (2015) investigated the influence of proximity to transit as a determinant of use of transit. Their study reported that people who live in close proximity to transit station report walking frequently and use transit for their trips resulting in reducing dependence of car in comparison to their counterparts who lived away from
transit stations. Another study is Pinellas, Florida in 2012 reported that most trips using bus were home-work/work-home trips with most users riding the buses for over 6 months in a year (Pinellas Community Bus Plan, 2012).

Quality of service is another determinant that impacts user perception and the use of transit. A transit user survey conducted in Walsall, England by a British automotive service company (RAC) in May 2008 investigated the attitude and opinion of public transport (metro and bus transport). They found that more than half of the respondents use public transport daily and mainly for work purposes. Majority of bus users were concerned about the frequency and reliability of the service, overcrowding, poor connection, and the bus conditions. The outcome of this analyses were targeted at improving the transit service quality and increase the mobility in the area (The RAC, 2008). Also, good accessibility to transit and its quality of service impacts the travel behavior of transit users and their pattern of use of transit for various trip purposes. A study conducted in City of Omaha in October 2012 reported that most people use the transit for work purpose, and they generally walk before and after using transit. Also, transit users ride the metro 5 to 7 days a week, and had used the service for more than five years (Omaha Metro On-Board Survey, 2012).

In summary, transit user behavior and the frequency and characteristics of their trips are influenced by the accessibility and proximity to transit stops, the quality of service and personal demographics. Understanding their behavior and the perception of use of transit service can have important implications for planning and development of efficient public transportation. Thus, many countries in the GCC region are now working on enhancing the transit service and its availability for its larger population.
TRANSIT IN GULF COOPERATIVE COUNCIL REGION

The Gulf Cooperation Council (GCC) region incorporates six countries, namely: Saudi Arabia, United Arab Emirates, Oman, Kuwait, Qatar and Bahrain. All of these countries experience similar topographical and weather conditions with respect to high temperatures and humidity most time of the year. Henceforth, several of major cities in this region are experiencing a rapid growth in car ownership and inefficient public transportation system owing to the ease of availability of financing by bank to own a car (Mahrez & Al Wahibi, 2014). This has resulted in severe traffic congestion and longer commute times (Belwal and Belwal 2010), leading to public agencies in these regions opting to enhance and provide an efficient public transportation system. However, for cities where public transit does exist, little is known about it its ridership and their trip characteristics.

Most studies about public transit ridership in the GCC region have reported that transit users are affected by the quality and frequency of service, access to transit, weather, built-environment, and other socio-cultural factors. For instance, transit user study in Doha, Qatar (Shaaban & Khalil, 2013) and in Oman (Mahrez & Al Wahibi, 2014) reported that users were affected by long wait time and hence wanted a better service with reduced headways. Also, the quality of transit service including comfort, safety and convenience affected the use of public transit and hence better service quality was recommended.

Access to transit influences an individual’s choice to use transit. The study in Doha reported that walking time to transit (Shaaban & Khalil, 2013) and unavailability of well-designed pedestrian environment in Al Riyadh, Saudi Arabia (Aldalbahi & Walker, 2016) affected people’s willingness to use public transit. The researchers of public transit use in Oman and Al Riyadh reported that weather was a major deterrent to transit use in the region. With
temperature in summer reaching up to 57°C, the thermal comfort of the outdoor environment made it difficult for individuals to walk and wait for public transit.

More recently, a study by Qamhaieh and Chakravarty (2016) investigated the social exclusion with regards to the use of public transit in the City of Abu Dhabi. Their study identified four dimensions of social exclusion which includes financial; Physical; organizational; and temporal. The authors conducted a semi-structured interview with transit users, survey of college students (non-users) and a cohort study of 20 study to analyze their experience using the public transit for the first time. They reported that the bus system in Abu Dhabi contributed to social exclusion by adding to the prejudices towards the riders, inefficient service in sense of speed, and lack of supporting infrastructure.

A structured survey of transit users can provide more and precise information about their transit trip purposes, perception of quality of service, transit user behavior such as trip frequency, and user characteristics. Information from such investigation can contribute greatly to efficiency of the transit system, understand user needs and perception, and provide better network of bus service, hence effective use of transit in the region, in Abu Dhabi as well as the GCC region. Implications from such studies is timely for the region given the immense development and several newly proposed transportation service improvements in the GCC region.

The GCC members have proposed an integrated railway network between Oman and Kuwait to improve their regional connectivity. Meanwhile Dubai, Riyadh and Doha have started to construct their national railway network, with the first phase of Etihad railway in UAE that will be used to transfer goods by rail from Shah and Habshan to the Port of Ruwais. Also, the Dubai Metro, a rapid transit system, covers 46 stations and carried about 190 million passengers in 2016. Abu Dhabi has proposed a metro rail that will cover about 131kms connecting the city
center to its surrounding islands and other important destinations in the emirate. Similar projects such as the new metro system in Riyadh in Saudi Arabia proposed in 2013 and a new rail system in Doha, Qatar have been proposed, which can benefit from implications of this study.

**METHODOLOGY**

**Capital City of Abu Dhabi**

Abu Dhabi, the capital city of the United Arab Emirates (UAE), is one of the largest cities in the country, located on the north-eastern region of the Arabian Gulf in the Arabian Peninsula with 10% of the world oil and 5% of natural gas reserves. The economic growth and the location of the city make it as a hub for business, markets, and tourism. The climate is tropical, semi-dry climate, with hot arid summers, warm winters and short rainfall. The average population growth is about 3.7% (2005 – 2014), with the largest share of population being immigrants from foreign countries (about 80%) who live in the city to work or to do business (SCAD 2015). The Urban form of the city is an auto-oriented design, with high percentage of car accessibility and strong road infrastructure network. In 2011 the city had 785,076 licensed motor vehicles which has increased rapidly with the population growth of the city (Abu Dhabi e-Government Gateway, 2016).

In 2008, the Department of Transportation (DoT), now reorganized as Department of Municipal Affairs and Transportation (DMAT), in Abu Dhabi introduced the Surface Transport Master Plan (STMP) embodiment to the transportation strategy developed by Plan Abu Dhabi 2030. The STMP is an integrated transportation plan that supports the economic growth of the city and improve the quality of life for its residents with a commitment to the society to insure sustainability and conserve environment. It is a comprehensive plan that include multiple modes
of travel combined with intelligent transport system to let all people benefit from the advanced technology in transportation. It aims to operate six components, highways, metro, train, rail, bus, and ferry and water taxi (Department of Transportation, 2009).

The DoT employed a travel pattern surveys in 2009, to study the travel behavior across the Emirate of Abu Dhabi including the Abu Dhabi metropolitan area, Al Ain and Al Gharbia. They found that above 4 million trips were made on the daily basis by the residents of Abu Dhabi using different modes of transportation. At that time 1% of those trips were undertaken by public buses, which is a small amount of the total daily trips generated in the city compared to the other modes. The main trip purposes were to reach the usual workplaces; for shopping; and personal businesses (Department of Transport in Abu Dhabi, 2012). That study was done more than 7 years ago, and the current situation is largely different, as the population and the economics of the city changed dramatically in the past few years. Also, this study targets to survey the transit users during peak summer season to understand their behavior and perception of transit use in extreme weather conditions.

**Study Stations**

Since 2011, the DoT operates about 650 buses over 95 service routes providing more than 50 million passengers miles of trips within the various districts of the Emirate of Abu Dhabi while operating 24 hours a day (Department of Transportation in Abu Dhabi, 2012a). For this study, 14 bus stations were selected on the main island of Abu Dhabi city located on two major roads (Sultan Bin Zayed the First St and Shk. Rashid Bin Saeed St.) that cut across the length of the city and are considered as the roads with high vitality and congestion (Onwani, 2015). The stations were selected based on total number of service routes and the frequency of service within and between Abu Dhabi and its suburbs (Department of Transportation in Abu Dhabi,
2012b). These top 14 stations lay on these two corridors of the city with a pair at each location providing service in opposite directions (Fig. 3).

![Location of Study Stations in Abu Dhabi Mainland](image)

**Figure 3: Location of Study Stations in Abu Dhabi Mainland**

**Survey Administration**

The transit users were randomly selected at each bus stops and the survey was administered from August 8, 2016 to August 27, 2016 (peak summer weather) including weekends between 7:00 to 10:00 in the morning and from 4:00 to 7:00 in the evening (peak commute time). A total of 251 fully completed survey responses were used for the analysis of this study. The survey included a total of 32 questions to be completed by the respondent within 10 minutes. The survey was divided to inquire five major information from the survey respondent and was approved by the
Human Subjects Research Ethics Committee in English and then translated to Arabic and Urdu (two majorly spoken language in UAE) by professional translators.

1. **Trip Characteristics**: Q1 to Q8 inquired about the trip taken during the time of the survey and every day, the location of the trip origin and destination (O/D), how they reached the bus stop from the origin and how they get to the destination after drop off and the time consumed for the same.

2. **Travel Behavior**: Q9 to Q15 inquired about the travel behavior of the user, the mode choice, length of transit usage, and the frequency of use.

3. **Trip Perception**: Q16 measured the user satisfaction, particularly about the availability of seating, the cost, the overall service, the reliability of the service, the frequency of the service, and the cleanliness inside the bus.

4. **Social Network**: Q17 to Q21 inquired about the respondent social circle and if their friends and families used public transit and their reasons.

5. **Personal Characteristics**: Q22 to Q32 inquired the respondents socio-demographic information.

The responses from the survey were used to understand the transit user and their trip characteristics; what service-oriented and individual characteristics act as barriers to use of transit while what influences the continued use of public transit, and what socio-demographic settings influence transit ridership in the city of Abu Dhabi.

**RESULTS AND DISCUSSION**

**User Demographics**
Transit users at the 14 study stations were inquired about their transit trip characteristics, their travel behavior and perception, the behavior of their social network (family and friends/co-habitants) with regards to transit use and their personal characteristics. Descriptive analysis of the respondent characteristics revealed that there were more males (60%) than females (40%) transit users.

Most of the respondents were in the age groups of 25-34 (55.8%) and 35-54 (33.9%) representing the working class age-group (Fig. 2). The population of Abu Dhabi includes 80% of the population that are expatriates, roughly half of these expatriates are low-income, blue-collar migrant workers (SCAD 2014). However, our respondent were 86% expats and 14% non-Emirati Arabic individuals which indicates none of the transit users were local Emiratis (Fig. 4).

Figure 4: Age and Ethnicity distribution of respondents
A recent study by Qamhaieh and Chakravarty (2015) indicated the prevalence of social exclusion among transit users in Abu Dhabi with Emirati’s non-preference of using public transit in the region. This study provides an empirical evidence of their discussion. However, the socio-cultural or personal preferences that influences these decisions remains to be investigates, which was outside the scope of this study.

**Household Demographics**

Household characteristics have an impact on the mode choice and the travel behavior of individuals (Skarin et al, 2017; Olde Kalter and Geurs, 2016). Transit use in Abu Dhabi, as reported earlier, is dominated by expats and those within the working age group of 18-54. Of all the respondents, about half of these live with their friends or extended family and only 20% with their spouse and/or children (Fig. 5). This follows the trend of the region, with the ratio of dependents per employed person in Abu Dhabi being 0.31 (UPC 2010, pg 7) indicating either most employed individuals are single and if married, live with friends and relatives. The marital status of the respondent indicates that more than half of the surveyors (56%) were single in comparison to 44% of the respondents who are married (Table 1).

Figure 5: Housing arrangement of transit users
Table 1: Housing arrangement for Single and Married individuals

<table>
<thead>
<tr>
<th>Marital Status/Housing</th>
<th>Family (Wife &amp; Kids)</th>
<th>Friends</th>
<th>Ext. Family</th>
<th>Other</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single</td>
<td>0</td>
<td>80</td>
<td>38</td>
<td>20</td>
<td>138 (56%)</td>
</tr>
<tr>
<td>Married</td>
<td>41</td>
<td>44</td>
<td>14</td>
<td>9</td>
<td>108 (44%)</td>
</tr>
</tbody>
</table>

Another important characteristic that explains this household composition in Abu Dhabi is the income versus rental cost of housing. The average rent for a prime two-bedroom apartment in Abu Dhabi is about USD 3175.00 (or AED 140000/year) per month (Abu Dhabi Real Estate Market Overview, 2013). However, the majority of transit users (about 65%) report a household income less than AED 5000 (USD 1360) per month (Fig. 6). This disparity of income to housing rent lends itself to most expats living in housing units (villas or apartments) with other single employed individuals.

Figure 6: Income and Access to Vehicles per Household

The low level of income tends influences the mobility of these individuals, as seen from the figure 6. Most transit user (63%) do not own a vehicle in their household and about 85%...
have one or less vehicles (Fig. 4). This lends itself to most of them either walking/biking or using public transit for their commute (both recreational and commuter trips).

**Trip Characteristics**

The respondents were inquired about the purpose of trip. This was done for both the origin and destination of the trip. For instance, respondents reported where they came from and where they were heading to for that particular trip. In the figure below (Figure 7), the inner doughnut represents the distribution of locations where the transit users came from and the outer doughnut represents the distribution of locations where they were heading at the completion of that trip. Most trips (both at origin and destination) were for home (O: 54.98%; D: 35.06%) or for work (O: 29.88%; D: 45.02%) indicating that most were heading to or coming from either work or home. Hence the majority of the trips were commuter trips while only about 11.5% of trips at origin and 13.55% of trip at destination were for recreational purpose (shopping; social visit and leisure).

![Figure 7: Trip purpose to and from transit (bus) station](image)
Commuter Trips

Traditionally, commuter trips occur during the weekdays and during working hours of the day. To understand the frequency of commuter trips and its occurrence (day and time), we analyzed the distribution of work-related trips based on the time (morning and evening) and day (weekday and weekend) when the survey was administered. The Table 2 below reveals that most trips in the morning originated from home (80) and ended at work (78) during day time and vice-versa work (49) and home (54) in the evenings during the weekdays, an obvious indication of commuter trips. Nonetheless, during the weekend, about 18% (22 of 120) of commuter trips originate from home of which about 60% ends at work destination (14 of 22). Also, over 20% of the commuter trips occur for individuals heading for night shifts. These are individuals either heading back from work in the morning or heading to work in the evening. It has to be noted that some trips that originated from home or from work ended at other destinations (indicated in boxes in table 2). This has implications for transit service frequency for late evening commuter trips indicating that transit agency in Abu Dhabi should provide sufficient service for these late evening commuters to work.

Table 2: Commuter trips during day and night time

<table>
<thead>
<tr>
<th>Trips</th>
<th>Morning Trips</th>
<th>Evening Trips</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Home to Work</td>
<td>Work to Home</td>
</tr>
<tr>
<td>Weekdays</td>
<td>80 2 78</td>
<td>13 7 6</td>
</tr>
<tr>
<td>Weekends</td>
<td>22 8 14</td>
<td>8 1 4</td>
</tr>
</tbody>
</table>

While most respondents on the day of the survey used public transit for commuter trips, they were asked to report the general purpose of using transit during the weekdays and weekends (Fig.8). The weekdays, as seen earlier, were usually for work-related trips with less than 10% for
shopping, social visit or recreation each and the weekends reported more non-work related trips. About 64% of weekend trips were recreation related trips such as shopping, social visit, restaurants and movies.

![Figure 8: Weekday and weekend trip purposes](image)

It can be inferred from the chart above that the weekday trips, about 48%, are for work-related trips and for the weekend about 65% are recreational trips. This indicates a need of higher frequency of services during weekend in routes that serve the recreational destinations. Also, it impresses on the need to have sufficient and not reduced transit services during the weekends as well. A well served network of transit service can hence improve the accessibility to work or non-work destinations for the transit users.

**Non-Commuter Trips**

The survey inquired respondent about access to various destination. Specifically, they were asked to report the mode they chose, the time it takes for them to reach that particular destination and the approximate distance at which these destinations were located. Most respondents reported using public transit or walk (at least 80%) to access these destinations (Figure 9). The primary mode used to access these destination was the public transit (bus) except for grocery shopping. This is a reflection of the characteristics of land uses in the super blocks of Abu Dhabi. Most of these blocks tend to have small retail establishments in the ground level of the buildings,
which includes fruit and vegetable vendor, provision stores and markets, laundry, restaurants and hair salon.

However, residents of Abu Dhabi tend to access big box establishments that sell everyday necessities and utilities at cheaper price. Similarly, Hamdan Street is a major hub for several remittance agencies and provide a competitive conversion rates that attract expats for remitting to their home country. The cheapest (or free) recreation spots in Abu Dhabi are the parks and beach (Corniche) along the coast of Abu Dhabi main land. Owing to high rental prices along the Corniche Corridor, most of the low-income household tend to live in apartments within the city center which requires them to use public transit for their recreational trip. Other administrative services such as post office, health services (hospitals) and banks are located at strategic locations in the city and hence requires that they travel longer distances and hence use public transit for the same.

![Graph showing trip share by mode for non-commuter trips]

Figure 9: Total Trip share by Mode for Non-Commuter Trips
The respondents also reported the time it took for them to reach each of these destinations. Considering a walkable distance of 10 minutes (ordinal scale measure), we inquired percentage of individuals who could reach each of these destination and the mode they used for the same. The table 3 below indicates that except for shopping and recreation, over 50% of the all respondents we able to access other service within 10 minutes. Also, walking was the most preferred mode for accessing most of these destinations except the recreational and health services. This indicates the availability of variety of land uses that are accessible by foot to its residents. Diversity in land-uses are associated with higher frequency of trips by walk and hence an improved built-environment within and around the super block that supports walking can enhance the walking experience of transit users and may encourage more walking trips in the community (Christiansen et al 2016; Maghelal, 2011). Also, walkable communities report higher physical activity, less use of private auto and increased use of public transit. Hence improving the existing built-environment to make it more walkable can influence transit use as well.

Table 3: Mode Share for trips to various destination within 10 minutes

<table>
<thead>
<tr>
<th></th>
<th>Bank</th>
<th>Health Service</th>
<th>Post Office</th>
<th>Remittance</th>
<th>Grocery</th>
<th>Shopping</th>
<th>Recreation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Car</td>
<td>2.16%</td>
<td>12.95%</td>
<td>5.88%</td>
<td>4.55%</td>
<td>3.68%</td>
<td>5.44%</td>
<td>8.20%</td>
</tr>
<tr>
<td>Bus</td>
<td>27.34%</td>
<td>21.58%</td>
<td>21.01%</td>
<td>18.18%</td>
<td>17.18%</td>
<td>16.33%</td>
<td>17.21%</td>
</tr>
<tr>
<td>Walk</td>
<td><strong>31.65%</strong></td>
<td><strong>16.55%</strong></td>
<td><strong>24.37%</strong></td>
<td><strong>38.64%</strong></td>
<td><strong>50.92%</strong></td>
<td><strong>21.77%</strong></td>
<td><strong>16.39%</strong></td>
</tr>
<tr>
<td>Other</td>
<td>0.72%</td>
<td>5.04%</td>
<td>5.04%</td>
<td>0.76%</td>
<td>1.23%</td>
<td>1.36%</td>
<td>1.64%</td>
</tr>
<tr>
<td></td>
<td><strong>61.87%</strong></td>
<td><strong>56.12%</strong></td>
<td><strong>56.30%</strong></td>
<td><strong>62.12%</strong></td>
<td><strong>73.01%</strong></td>
<td><strong>44.90%</strong></td>
<td><strong>43.44%</strong></td>
</tr>
</tbody>
</table>

Transit Access and Egress

The figure 10 shows the mode choice for the public transit users before and after the trip on the day of the survey and for everyday trips. Most transit users walk to the bus stop from the origin of their trip (Everyday: 85% and today: 78%) and tend to walk to their destination as well.
(everyday: 84% and today: 73%). Walking being the most preferred mode from and to bus stations, the location of bus-stops affects the access by walk. Henceforth, the stops should be positioned along the edges of the superblocks such that it minimizes the distance to the stops providing maximum accessibility to its residents.

The next preferred mode (about 15% everyday) for their trip to and from the bus stops is using another bus service. This indicates a pattern of linked transit trips that helps commuters get to and from their destinations every day. As Abu Dhabi’s new Department of Municipal Affairs and Transportation, attempts to enhance its public transit service (STMP, 2008), it is important to understand the origin-destination of the entire trip and investigate opportunity to provide direct bus service to these job destinations, as one of the biggest problem in transit service use is the availability of services with minimum transfer time (cost) (Huang et al., 2016).

Figure 10: Mode of travel to transit stop on the day of survey and everyday

The other types of modes include taxi service and informal shuttle buses used by low-income expatriates. It is interesting to note that even after boarding a taxi and shuttle buses, these transit users transfer to public bus services to get to their destination. This linked trips by
different modes requires an in-depth inquiry to better understand this behavior by transit users in Abu Dhabi

As indicated earlier, walking is the primary mode of travel to bus station. Previous research on walking to transit has reported that distance to transit is one of the major determinants of individuals who chose to walk to transit stops. Based on walking speed of 3km/hour, we evaluated the walking trips taken during the weekdays, weekend, a combination of few weekdays and weekends or all days (only) for a typical transit-oriented development distances to transit (Durand et al, 2016; Maghelal, 2011). For example, walking trips that took up to 8 minutes were evaluated as 400m distance (quarter-mile), over 8 to 16 minutes were evaluated as 800m (half-mile) and from 16 to 32 minutes (one-mile) were evaluated as 1600m distance. Any travel time as reported by the respondents over 32 minutes were aggregated as over 1600m distance.

<table>
<thead>
<tr>
<th>Trip Days/Trip Time</th>
<th>1-8 min (400m)</th>
<th>9-16 min (800m)</th>
<th>17-32 min (1600m)</th>
<th>Over 32 min (&gt; 1600m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Only Weekdays</td>
<td>39.65%</td>
<td>44.83%</td>
<td>13.79%</td>
<td>1.72%</td>
</tr>
<tr>
<td>Only Weekends</td>
<td>50.00%</td>
<td>41.67%</td>
<td>4.17%</td>
<td>4.17%</td>
</tr>
<tr>
<td>All Days</td>
<td>53.75%</td>
<td>32.14%</td>
<td>8.04%</td>
<td>6.25%</td>
</tr>
<tr>
<td>Weekday/Weekend</td>
<td>45.45%</td>
<td>27.27%</td>
<td>27.27%</td>
<td>0.00%</td>
</tr>
</tbody>
</table>

Majority of trips by walk to the transit stops were from a generally accepted walkable distance of 400m for weekends (50%), all days (53.75%) and for combination of weekend-weekday (45.45%) trips (Table 4). Majority of trips taken during weekdays were within a walkable distance of 400 to 800 meters (44.83%). As reported by previous research on walking to transit (Lachapelle et al, 2016), this study also observed a large percent (about 80% of all trip-days) of walking trips to transit originate within a distance of half mile (800m). Therefore, the
focus to retrofit the built-environment that not only enhances the walking experience of current transit users but also increases the general walking trips should be targeted within the area of half-mile from the transit stop.

**Influence and Barriers to Use of Public Transit**

This study inquired about the influences and barriers including possibility of mode shift from public transit by the current users of public transit. Some of these include the reasons for using public transit in general and in-comparison to other modes of travel, barriers/inconvenience to use of transit for their trips, and the perception of quality of transit service.

![Bar Chart](image.png)

Figure 11: Reasons for use of transit and alternative mode choice
The primary reason for using transit is driven by the socio-economic status of transit users. Since majority of transit users are below a monthly income of AED5000, they reported using public transit because it was either cheap (39%) or because they did not own a car (53%) (Fig. 11). This study also asked the transit users to report the primary mode of travel they would chose for their trip if the bus service was not available. This was inquired because transit service in Abu Dhabi was introduced less than a decade ago, and even then most used taxi service to get to their destinations. Majority, as expected reported using taxi or using carpool with someone, if there were no bus service. Public transit in Abu Dhabi was introduced in 2008 to reduce the dependency on taxi and private vehicle and this indicates the effectiveness if availability of transit service, especially for low-income individuals.

<table>
<thead>
<tr>
<th>Table 5: Measures of quality of transit service</th>
</tr>
</thead>
<tbody>
<tr>
<td>Statement</td>
</tr>
<tr>
<td>Availability of seating</td>
</tr>
<tr>
<td>Cost of ride</td>
</tr>
<tr>
<td>Overall service</td>
</tr>
<tr>
<td>Reliability of service</td>
</tr>
<tr>
<td>Frequency of service</td>
</tr>
<tr>
<td>Cleanliness inside bus</td>
</tr>
</tbody>
</table>

Although, the availability of public transit has effectively reduced the use of taxi, the quality of their service needs has room for improvement. Perception of good quality of transit service not only encourages current users to use transit more frequently for other trip purposes, but may also attract non-public transit users to use public transit for future trips.

For instance, when inquired about the availability of seating and frequency of service (Table 5), the respondents reported and average of 3.4 (1 being poor and 5 being excellent). This indicates the need to have a frequent service or larger capacity buses for the convenience of
current transit users. Another probable reason for non-availability of seating could be because of the cultural need to the region such that the front of the bus is reserved for females and back half for men. However, the mean difference for men and women in regards to availability of seats was statistically insignificant.

Most respondents reported that the buses were generally clean inside with mean of 4.2, while the cost of ride and reliability of service reported an average of 4 and 3.9 respectively. The overall quality of service averaged at 3.9 indicating good service in general. It is encouraging to see the success of transit service in connecting people from their origin to their destination.

Increase in frequency of service would help enhance the service quality and could also improve the perception of reliability of the service. Henceforth, the DMAT of Abu Dhabi, may consider increasing the frequency to achieve its STMP 2030 goal of quality public transit to its residents. However, the frequency should be in accordance to the weekday-weekend and commuter-non-commuter trips as reported by the respondents.

CONCLUSION AND IMPLICATIONS

One of the major goals of the Surface Transportation Master Plan of Abu Dhabi is to enhance the use of sustainable modes of transportation including increased walking, biking and public transportation. Therefore, this study assessed the trip characteristics; travel behavior; perception of quality of service, social network and personal characteristics of transit users. However, researchers of this study understand that this is an exploration of transit user preferences and perception of Abu Dhabi bus service, and hence have both land use and transit implications for the city and GCC region in general, but not for general transit ridership in other regions.
Land Use and Built-Environment Implications

The Urban Planning Council (UPC) have recently started demolishing structures in city area that are dilapidated or visually unappealing and old. The redevelopment of these in-fills should consider accommodating working age group (18 to 54 years) single (bachelor) worker housing, as majority, married or single, tend to share housing with other single or married individuals without wife and kids. Developments around the transit station should include affordable housing for these single working individuals to afford the rent.

The countries of the GCC are currently experiencing a shortage of housing, particularly for their proportionately large and growing population of low-income residents. From 2000 to 2013, the total population of the GCC rose by over 67 percent (beyond affordability) and has been gradually increasing at the rate of 3% annually. Hence residential development that can accommodate low income expatriates living with friends should be the target development around the transit stops. Also, other land uses that serve the needs of low-income single living such as retail, cleaning, stationary, grocery and other administrative uses such as post-office and remittance office can be accommodate within the stations catchment area.

The current land use mix of the super block accommodates a variety of services such as retail, commercial and administrative services. This encourages higher number of walking trips to these destinations. However, this is just one of the seven dimensions that influences walking trips in general (Ewing & Cervero, 2010). Improving density and design dimensions of the built-environment can enhance the walking experience and encourage more people to walk within and around the super block area. At present, the pedestrian infrastructure does not provide shade, comfort, and convenience of walking, which are critical for a good walking environment.
Since the most common mode of travel to and from the bus stops is by walk, especially within the catchment area of 800m (or half-mile), conscious efforts should be taken by the UPC and the municipality to improve this access and probably plan for infrastructure that can support biking to and from the stops as well. This could help larger group of the low-income residents to use public transit for short and relatively long trips within the city area. Also, the large super block sizes make its unfeasible for individuals wanting to use transit to use transit in summer. Hence both built-environmental retrofit that improves the thermal comfort of individuals walking to transit and location of transit stops should be planned to mitigate the impact of such barrier to transit use. Built-environment interventions to pedestrian infrastructure that can enhance the walking experience of transit users can be proposed, especially that can make it bearable during peak summer time when the temperatures exceed 45 degrees Celsius.

As for the issue of social exclusion, this study provides empirical data suggesting that public transit in Abu Dhabi seems to create an unintended segregation among different ethnic and social groups. Hence public transportation should try to include all potential users of the system in its future planning (Qamhaieh and Chakravarty, 2016).

**Transit Service Implications**

As observed from the study, the most targeted destinations are housing and jobs and hence the proximity between these two points is the best way to reduce the travel time and distance. Therefore, the alignment of origins and destinations with the transit network is needed for a good accessibility of a region (Transit-Oriented Communities, 2010). This alignment should be considered for both traditional and night commuter trips. Also, the majority of non-commuter trips to recreational and retail services involves trips by public transit and walk, most of which occur during weekends. Henceforth, weekend trips to these destinations (such as Saadiyat Island
or Corniche) should also be considered for efficient service planning and frequency of services. When these destinations are within 10 minutes’ distance, residents tend to walk more than use public transit or private auto. Hence planning policies that reduce the use of cars through supportive transportation infrastructure, land use planning and that can direct the service and financial policies to non-motorized modes (Kenworthy & Laube, 1999) should be incorporated in their planning approach. Easy access to and from this destination by public transport can encourage people to use the bus service at present and other transit services such as metro and light rail system planned for the future.

Most transit users walk to and from transit stops as distance seems to have a significant impact on their choice to walk. Over 80% of the trips, for weekdays, weekends or combination thereof, to transit is done by walk when the distance to these stops are within half-mile (or 800m) of the transit stop. Earlier studies have shown an inverse relationship of income and transit ridership. This study observed a similar trend with larger group of low-income individuals not owning a car and choosing transit as it is the cheapest mode of travel available to them. However, it is clear that unavailability of transit would force them to use the taxi service for their travel. This is encouraging in sense that the STMP plans to introduce more options of public transit in and around the city. However, careful consideration should be given to the cost of the fair, so as to make those services affordable for these low-income users as well.

Finally, the transit service quality can be improved by targeting specific short-comings as reported by the current transit users. For transit to be well regarded, public transport services must follow regular schedules, be safe and rapid, guarantee high service quality, and utilize resources efficiently (Dridi et al. 2005). These can encourage other potential users to shift from other modes to using public transit as their primary mode of travel, the actual intent of the
introducing public transit in Abu Dhabi since 2008. One specific target change in service that Department of Municipal Affairs and Transportation of Abu Dhabi can accommodate is by reducing the headway time of the transit system and hence result in increased frequency of service. As Abu Dhabi plans for next phase of public transit (light and regional rail), understanding the travel choice, travel behavior and perceptions of current transit user can feed into planning better transit system and enhance transit user experience in Abu Dhabi. What remains to be seen is, with everything else remaining equal, if the introduction of the new transit systems in Abu Dhabi will help reduce the stress on one system of transit and possibly improve the overall transit ridership in future.

REFERENCES:

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https://dot.abudhabi.ae/ckfinder/userfiles/files/Abu%20Dhabi%20Travel%20Patterns_Highlights%20of%20the%202009%20Survey%20Results.pdf


# Public Transit User Survey

Please take a moment to fill out this form. When you’re done, please give the questionnaire to the investigator.

## This Trip

1. **Where did you come from on this trip? (check one)**
   - Home
   - Work
   - School/College
   - Medical
   - Other

2. **Where was that place? (street or landmark)**

3. **How did you get to the bus stop generally?**
   - Today
   - Everyday
   - Walk
   - Drive my own car
   - Transfer to another bus
   - Ride a bike
   - Be biked by someone
   - Other

4. **How much time does it take you to get to the bus stop?**

5. **Where are you going on this trip?**
   - Home
   - Shopping
   - Work
   - School/College
   - Medical
   - Other

6. **Where is that place? (street or landmark)**

7. **How will you get to that destination from the bus stop?**
   - Today
   - Everyday
   - Walk
   - Drive my own car
   - Transfer to another bus
   - Ride a bike
   - Be biked by someone
   - Other

8. **How much time does it take you to get to your destination from the bus stop?**

## About your Travel

9. **How long have you lived in the region (UAE/Abu Dhabi)?**
   - Less than 1 year
   - 1 year
   - 2 years
   - More than 2 years

10. **How long have you been using public transit?**
    - This is my first time
    - Less than 6 months
    - Between 6 months to 1 year
    - Between 1 year to 2 years
    - More than 2 years
    - Through my stay in the UAE

11. **Do you own a car?**
    - Yes
    - No

   **If Yes, why are you using the public transit?**
   - I prefer using public transit
   - My car is being repaired
   - My car is being used by another family member
   - It’s cheaper
   - Other: ____________________

1
12. What is the major reason you are using public transit?
   - [ ] I don’t own a car
   - [ ] My employer doesn’t provide carpooling
   - [ ] My Apartment mate/friend use public transit
   - [ ] Cheaper to use public transit

13. If bus service is not available, how will you get to your destination?
   - [ ] Drive/Carpool
   - [ ] Walk
   - [ ] Use taxi
   - [ ] Ride a bike
   - [ ] Would not make this trip

14. Generally in which days do you use public transit in a week?
   - [ ] Sunday
   - [ ] Monday
   - [ ] Wednesday
   - [ ] Tuesday
   - [ ] Thursday
   - [ ] Friday
   - [ ] Saturday
   - [ ] Everyday
   - [ ] Not in weekdays
   - [ ] Not in weekends

For what purpose do you use public transit?

<table>
<thead>
<tr>
<th>Week Days</th>
<th>Trip purpose</th>
<th>Week Ends</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Home</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Work/School</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Social Services</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Recreation (Park, Movie)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Other</td>
<td></td>
</tr>
</tbody>
</table>

15. What mode do you use to perform following functions?

<table>
<thead>
<tr>
<th>Destination/ Function</th>
<th>Mode used</th>
<th>Time to get there (in minutes)</th>
<th>Distance to get there (in Kilometers)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Car</td>
<td>Bus</td>
<td>Walk</td>
</tr>
<tr>
<td>Bank</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Health service</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Post office</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Remittance office</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shopping (Grocery)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shopping (others)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Recreation (park, entertainment)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Your Opinion of using Public Transit
16. Please rate the following statements using 5-point rating scale: (circle one answer for each statement)

<table>
<thead>
<tr>
<th></th>
<th>Poor</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>a) Availability of seating</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>b) Cost of ride</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>c) Overall service</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>d) Reliability of service</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>e) Frequency of service</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>f) Cleanliness inside bus</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>

17. Is the weather in these days encourages you to walk and use the public transit more:
   □ Yes      □ No

Social Network
18. How do your family/friends usually travel to work/recreation/shopping?
   □ By car      □ Walking      □ Using public transit      □ Other___________

19. Would you use public transit if your employer provides carpooling at some nominal fee?
   □ Yes       □ No       □ My employer don’t provides carpooling □ I am not an employee

20. Would you use public transit if one of your apartment mates buys a car and you share fuel expense?
   □ Yes       □ No      □ I don’t have an apartment mate      □ I don’t know

21. Do your apartment mates/family work in the same location?
   □ Yes      □ No

22. Do any of your family members or friends use the public transit?
   □ Yes      □ No

   If Yes how many persons do use the public transit ____________________________

   Why do you think they use or don’t use the public transit? ____________________
**About Yourself**

23. Are you ...? □ Male □ Female

24. Your age is □ Under 18 □ 18 - 24 □ 25 - 34
□ 35 - 54 □ 55 - 65 □ Above 65

25. Are you....? □ Local Emirati □ Arabic □ Foreign/Expat □ Other ________

26. Are you □ Single □ Married

27. You live with □ Family (wife and children) □ Friends
□ Ext. Family (Relations) □ Others ____________________

28. How many Vehicles are in running condition and available for use by your household?
□ 0 □ 1 □ 2 □ 3 or more

29. Do you live in a
□ Villa □ High rise building (over 6 stories) □ Low rise building (less than 6 □ Other ________ stories)

30. How many people live in your home? (including yourself) ___________________________

31. How many people in your home are licenced? ________________________________

32. Your household average age is:
□ Under 16 □ 18 - 24 □ 25 - 34 □ 35 - 54 □ 55 - 65 □ Above 65

33. What was your monthly household income in Dirhams?
□ Under 1000 □ 1000 – 2999 □ 3000 - 4999 □ 5000 or more

34. Have you done this survey before?
□ Yes □ No

35. We want to invite to participate in our future study by using a device that calculate your physical activities, are willing to wear it?
□ Yes □ No

If Yes, Please provide the following and we will contact you soon:
- Email address ........................................................................
- Mobile Phone No. ....................................................................

Thank you for your participation!