

Demand and Supply Implications of Regular Public Transportation System for Policy Makers: A Case Study of Kandahar City, Afghanistan

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Kandahar city of Afghanistan being one of the largest cities of the country does not have any regular system of public transportation. The current system is limited to Paratranist only which operates as an informal system and is owned, operated and regulated by individuals and/or private unions. This study aimed to elaborate the characteristics and usage patterns of the current system and assess the need of a regular bus system within a framework of sustainable policy. The data was collected by using Revealed and Stated Preference techniques and analyzed with the help of MNL, two NL and a Binary Logit model to identify most contributory factors for obtaining the demand-supply equilibrium and making a policy for a regular bus system. The result of the models suggest that the residents of Kandahar city are more sensitive to travel time of a public mode compared to the travel cost. In other words, speed, waiting time, number of stops/stations and the distance between the stops will play a vital role in terms of ridership. Additionally, age and income are also important factors in planning of the bus system.

Key Words : Bus, Policy, MNL & NL, Kandahar, Afghanistan.

1. INTRODUCTION

Kandahar City being one of the 3 largest cities in Afghanistan is located 457km southeast of Kabul (Capital City of Afghanistan). The Central Statistics Organization of Afghanistan¹⁾ recorded the population of Kandahar City at 448,262 persons in 2016, however this population was 385,700 people in 2011 which shows a clear growth. This increment of population has caused an expansion and development of the urban center filled by low-income houses and crowded streets. These developments have generated some serious challenges for transportation providers and policy makers as they have to respond to the growing demand of transportation by providing convenient means of transport while simultaneously ensuring the economical, safety, environmental and other social demands. On the other hand, the dominance of private cars and motorcycles have also created several complications by contributing to traffic congestion, air pollution and other health

related problems. Similar to other developing cities, motorcycle is the most dominant mode of transport in Kandahar City followed by private cars. Low income families are mostly dependent on use of motorcycles while medium to high income families may own both motorcycles and cars. Low prices and ease of usage make motorcycles the first choice for the residents of Kandahar City.

Currently, the public transportation system of Kandahar city is limited to paratransit only with three main types of paratransit vehicles operating as an informal transport system. The majority of the vehicles for all three types are owned and operated by individuals with very limited control from the government. Due to lack of rules and regulations from the government in terms of vehicle ages and maintenance, most of the vehicles, particularly, the taxis are decades old. With respect to their operational characteristics, taxis can be divided into two categories. First type comprises the taxis with flexible routes, schedule and fare. Like other ordinary

taxi systems, the taxis under this category operate throughout the whole city and pick the passengers at any location. These taxis do not have any metering system; therefore, the fares are always flexible, negotiable and much higher than the second category. On the other hand, some taxis operate on fix routes. Terminals are provided at both ends of the routes where taxis can wait for their turn. These systems are operated by small “Taxi Unions” which are responsible for certain routes (mostly one route). As the routes for these systems are fixed thus the fares are also fixed. The fares of these taxis are much lower compared to the ones operating on flexible routes as the fare is shared by individuals. Another unique character of this sector is that the taxis are operating like vans and buses. Everyone can ride the taxi and it will not move until all the seats are occupied which results in generating few minutes of waiting time; particularly, during off peak hours. Likewise, majority of Zaranj-taxis are also operating on fixed routes with fixed price. On the other hand, all rickshaws are controlled and operated by individuals i.e. drivers and/or owners. Rickshaws of Kandahar city never operate on fixed routes which results in negotiable fares and flexible schedules.

The paratransit system of Kandahar city has number of deficiencies in terms of level of service; the most crucial being the irregular services provided by the system. Similarly, the existence of very old vehicles, lack of attention to safety regulations and fluctuations in fares are other problems associated with the current paratransit transport. Considering these problems, the governmental policy makers are trying to introduce alternative public modes in accordance with sustainable transportation policies to attract private car users.

On a general basis, policy-making could be defined as a process of providing a balanced response to the demands of various social groups. Normally, different groups will strive for their own benefits which may contradict the interests of other groups¹⁾. According to the findings of ²⁾ the policies for public transportation could be divided into two categories: (1) will include the policies that would respond to the current demand of public transportation and (2) those policies that would increase the share of public transportation in daily trips.

Generally, the planners and decision makers confront tough multicriteria decisions in terms of selection of the appropriate alternatives, various mode choices and some environmental impacts. And these decisions involve different interest groups, elected officials, the governmental agencies and the public²⁾. Even some observers have categorized the decisions

of public transportation system as both political and tactical process³⁾.

Choosing an appropriate system of public transportation is of the most important subjects in policy making with respect to the economic conditions and city status. Some of the most influencing factors in choosing a public transportation system are:

- Economical factors – these factors may include the overall capital cost i.e. the cost of establishing the sector, purchase of the fleet and equipment; operational costs and the subsidies paid by the government.

- Social factors – assisting the development of the cities by application of modern transportation system, providing a reliable and high quality public transportation, decreasing the rate of accidents by improving the safety measures, providing cheaper services, ensuring the passenger comfort, controlling the waiting and travel times and offering the transportation on all links for all levels of income.

- Environmental factors – strict consideration of issues related to the pollution of water, soil and air; the consumption of energy, land occupation and other factors related to the scenery and visual effects^{4,5)}.

Being one of the most used modes of public transportation systems in developing countries, bus systems are playing a vital role in transporting people. As other modes, bus network planning is a complex process which include a simple and legible network by ensuring the frequency and special coverage criteria. Findings of the researches show that concentration on these principles should increase patronage^{6,7)}, however, quantitative evidence is often unclear, particularly with respect to the nature of trade-offs. In these planning processes, the trade-offs are regularly created between the frequency and coverage as well as between coverage and direct services in response to budget constraints⁸⁾.

Other important concern in terms of preparation of policy for bus system is consideration of the ridership. according to Transportation Research Board⁹⁾ the ridership of bus could be affected by two types of factors namely “external” and “internal”. The external factors are those that could directly affect the demand and supply of the transit. Normally, these factors include all issues which are outside of bus agencies’ direct control. Population growth, economical conditions of the residents, fuel prices and ownership of private vehicles can be good examples of the external factors. On the other hand, the internal factors are considered the ones over which the service providers have some level of control such as quality of service which include availability, ac-

cessability and reliability on the services.

Researchers have found that planning a bus system may need extensive work from the government and/or private sectors. The very first trade-off for planning and operating a task occurs between operating costs and level of service. The initial and important expectation of the users is to get to their destinations quickly. However, this “quickly” is composed of total travel time for access to/from stops, waiting, in-vehicle and transferring. Other expectations of the users may include reliability and comfort. For realistically making this model to work, these measures should be sufficiently weighted with respect to each user’s behaviour^{10, 11, 12, 13}. On the contrary, the operators also expect a profitable system by having low driver wages and vehicle operating costs. This process of planning includes all decisions that should be taken prior to the operation of the system which is called Transit Network Planning (TNP).

This trade-off exists in introduction of a bus system in Kandahar city as well. For having an effective and reliable bus system, the government should prepare a comprehensive TNP by considering both users and operators i.e. demand and supply sides. With reference to current and planned road networks the TNP should consider the low income residents, the trends of private vehicle ownership, the daily trip patterns of the public and other social, cultural and local circumstances.

Moreover the government should consider the acceptance of certain levels of subsidies for the bus system at initial stages. For public transport the subsidies are common examples of second-best policy. Attention should also be paid to the policy of subsidizing a bus company as these policies affect the efficiencies of bus services¹⁴.

2. METHODOLOGY

(1) Data collection

The data for this study was collected through use of two different questionnaires. The first questionnaire designed for this study was divided into 3 main parts. The first part of the questionnaire was designated to the heads of the households and comprises some general questions regarding residence, vehicle ownership, income and family structure (family members’ information). The second part of the questionnaire is designed for collecting the data regarding one day trip for a normal working day in the middle of the week. This section asks the respondents to register all of their trips for one normal

working day. The characteristics of the trip include the start and end time of the trip, trip purpose, mode chosen for the trip, and total distance travelled. The final part of the questionnaire is designed for Stated Preference survey. The SP survey is designed in accordance to (L27 -A313-10 Fractional Factorial Design). Four options of transportation modes such as private car, private motorcycle and taxi (currently available modes) and bus (future plan), were selected to prepare SP choice sets. The private modes have two attributes (i.e. travel time and travel cost) and every attribute has three levels. The public modes (Taxi and Bus) have three attributes (i.e. travel time, waiting time and travel cost) at three levels each. On the other hand, an extra three-leveled attribute of income was also introduced to the design. This attribute asks the respondents to choose an option with respect to the changes in their monthly incomes. As the total number of runs for this design using the fractional factorial method (27) is too many for one person to answer therefore, the options were divided into 9 groups resulting in three options for each group (set). Eventually, these three sets are placed in each questionnaire and the respondents are asked to select one mode of transportation (car, motorcycle, bus and taxi) from each set.

In order to make it more understandable each part of the questionnaire was separated from other parts by printing them on different colors. A completed (filled) sample was also attached to the questionnaires. The questionnaires were distributed at universities, schools, restaurants and other offices. The maximum allowable number of individuals from one family to fill the questionnaires was set as five persons per family. The survey was conducted in September and October of 2016. A total of 1500 questionnaires were distributed to 300 households from which around 1000 were returned and/or collected and 603 questionnaires coming from 180 households were found eligible for use in the study.

On the other hand, we also wanted to study the supply side (i.e. drivers) of the existing public transportation sector. To do so a second questionnaire was designed for surveying the paratransit drivers in Kandahar City. This questionnaire was also divided into three main parts. The first part comprises some socio-demographic and family members’ information. The second part of the questionnaire was designated to questions related to the paratransit vehicles such as age of the vehicle, type of gas/fuel used, maintenance and other expenses of the vehicle etc. The final part of the questionnaire asked the drivers regarding various aspects of their jobs as well as some questions related to quality of

life (QOL). As most of the paratransit drivers in Kandahar city are illiterate, therefore, the method of the survey was chosen to be face-to-face interviews. This survey was also conducted in September and October of 2016 and five professional interviewers were hired and trained to interview the drivers. A total of 480 drivers were approached, 263 drivers agreed to take part in the survey; 63 drivers did not answer all parts of the questionnaire which resulted in 200 completed and eligible samples.

(2) Method of analysis

After the completion of the surveys a data base was developed for digitizing responses, cleaning outliers and imputing missings. Later, an overall aggregate analysis was conducted and several graphs and tables were obtained. Finally, the mathematical function of discrete choice modeling approach was chosen for analysis of SP data. More precisely, the technique of Multinomial Logit Model (MNL), and two types of Nested Logit Models (NL) were used for the analysis. On a general basis a typical multinomial logit model has the following form:

$$Pr(i) = \frac{\exp(V_i)}{\sum_{j=1}^J \exp(V_j)} \quad (1)$$

where,

$Pr(i)$: is the probability of the decision-maker choosing alternative i and

V_j : is the systematic component of the utility of alternative j.

Similarly, the utility of an individual (n) from mode j, V_{jn} , was derived as a linear function of explanatory variables:

$$V_{jn} = C_1 + \beta_{1j} X_{1n} + \beta_{2j} X_{2n} + \dots + \beta_{qj} X_{qn} \quad (2)$$

where,

C_1 : is alternative specific constant for mode j.

$\beta_{1j}, \beta_{2j}, \dots, \beta_{qj}$: are coefficients associated with explanatory variables.

$X_{1n}, X_{2n}, \dots, X_{qn}$: are explanatory variables for individual n, and

q : is Number of explanatory variables in the model.

As mentioned earlier after obtaining the results of MNL, we wanted to check whether the public modes and private modes have some shared attributes. Therefore, we divided the SP modes into sub groups and created two nested models shown in Figure1.

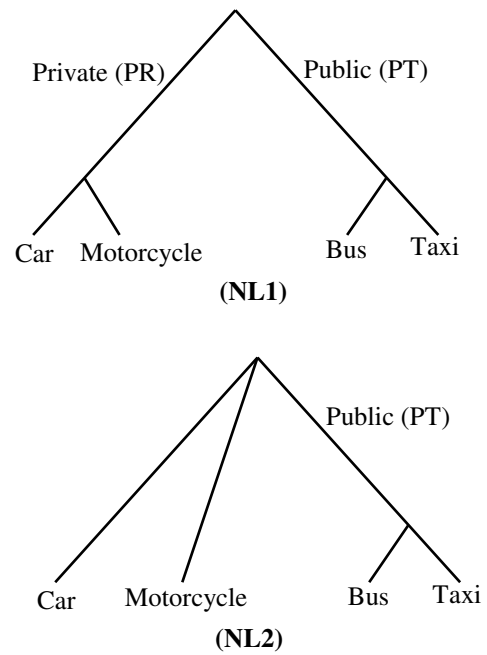


Fig.1 Nested Logit structures

3. RESULT AND DISCUSSION

(1) Descriptive analysis of household and individual data

As it was discussed earlier, a maximum of five individuals were permitted per house to participate in the survey. The demographic results show that most of the respondents are of young age. 38.5% aged between 20 and 30 years followed by even younger participants of ages 10-20 which makes 25.2% of the total. The portion of female participants is very small (12%) compared to (88%) of male respondents. 53% of respondents are married and 62% stated that they do not own any type of driving license. The education level of the respondents is also good in context of Afghanistan. 34% of participants hold bachelor degrees and 31.5% and 14.9% have attended high school and secondary school respectively. The occupations of the respondents include a variety of professions. However, the maximum number of participants are students with a percentage of 37.9. The second largest number of participants are self-employed which comprises 23.3% of the total. This is followed by the governmental workers with a percentage of 15%. On the other hand, if we look at the monthly income rate of the households; it is very much in the range of medium-to-high in the context of Afghanistan. 21.7% of respondents have mentioned that their household monthly income falls in the range of 20,000-30,000 followed by 10,000-20,000 and 30,000-40,000 with a percentage

of 20.6% and 13.9% respectively. The results also show a very high rate of private vehicle ownership for the residents of Kandahar City. According to the results, from 180 interviewed households; 179 which make 99.44% reported to have at least one type of a vehicle including bicycles. Particularly the motorcycle ownership is very high where 87.2% of the households owning at least one motorcycle. Similarly, 66.1% of the households reported ownership of at least one car on a family level. Other details of the demographics are presented in Table 1.

(2) Analysis of demand (the users)

This study recorded a total of 1937 trips made by 603 individuals for one working day. This gives us a mean value of 3.21 trips per person per day. As it can be seen from Figure 2 the maximum number of trips are made for going back to home (43.9%). The second and third positions are occupied by work and education trips with 20.0% and 18.9% respectively where the shopping trips are positioned four by having a value of 3.9%. Furthermore, the results

show (Figure 3) that most trips are made by using motorcycles which comprises 45% of the total trips. Car is the second dominant mode which is used for 23.3% of the trips. However, the most important issue is the limited use of public modes with only 4.4% value.

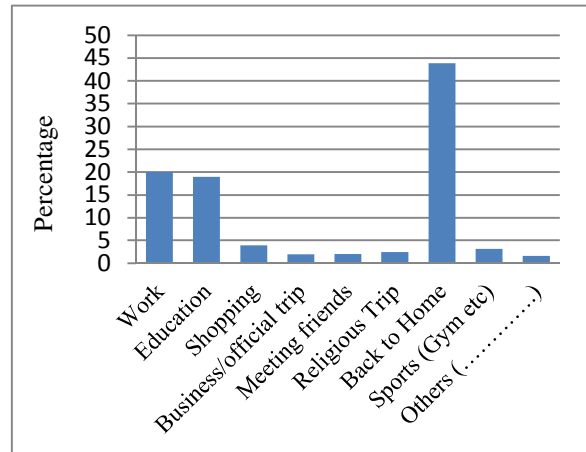


Fig.2 Distribution of trips with respect to trip purpose

Table 1 Descriptive statistics of demographic characteristics of respondents

Characteristic	Portion (%)	Characteristic	Portion (%)		
Age	1-10	3.8	No Income	1.7	
	10-20	25.2	Below 5000	0.6	
	20-30	38.5	5001-10,000	9.4	
	30-40	16.3	10,001 -20,000	20.6	
	40-50	8.3	20,001-30,000	21.7	
	50-60	5.8	30,001-40,000	13.9	
	≥60	2.2	40,001-50,000	13.3	
Education	Master / Doctor	4.0	50,001-80,000	10.0	
	Bachelor	34.0	80,001-100,000	3.9	
	High School	31.5	>100,000	5.0	
	Secondary School	14.9	House Ownership	Own the house	81.0
	Primary school	4.5	On rent/lease	19.0	
	Religious Studies	2.5	Marital Status	Single	47
	Literate (read &write)	2.7	Married	53	
Occupation	Illiterate	6.0	Gender	Male	88
	Government Worker	15	Female	12	
	Self-employed	23.3	Driving Licence	Own Licence	38
	Private Firm/NGO Worker	7	Do not own any	62	
	Teacher/Instructor	10.9	Car Ownership	Yes	66.1
	Student (Education)	37.9	No	33.9	
	Housewife	1.5	Motorcycle Ownership	Yes	87.2
No Occupation/Retired	4.4	No	12.9		

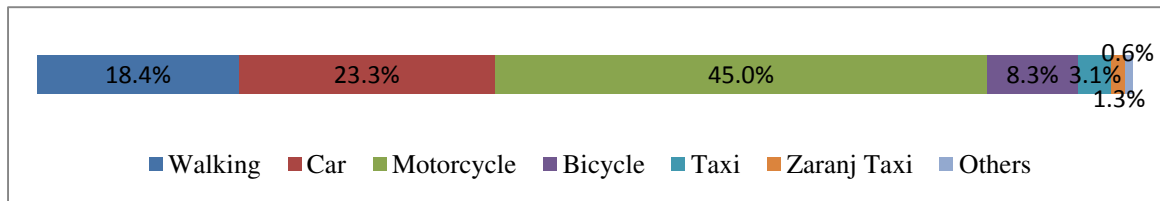


Fig.3 Distribution of mode share in daily trips

(a) Results of MNL and NL

As explained earlier, the SP sets included four modes of public transportation. The respondents were asked to select one mode with respect to their attributes. The responses were then analyzed through use of Multinomial Logit Model (MNL) approach. Estimation results of multinomial logit model showed that the residents of Kandahar city give more importance to the travel time of their trips compared to the cost. however, the coefficient for the cost in the result of MNL is also significant suggesting the importance of cost as well. In other words the coefficient of the cost suggests that the fares of the public modes should be controlled which may attract more riders for the public modes. For the travel time it is necessary to pay special attention to all issues that could affect the travel time of a new public mode.

These specifications could be summarized as follow:

- *Stop/Station design*: the location of all stops and the distances between the stops can play an important role in reduction of waiting time.
- *Headway*: The headway between buses are also the factors that could contribute to changes in travel and waiting times.
- *Speed*: The design speed of vehicles should be selected very carefully.

On the other hand, income level of households and age of the users may also put an impact on the mode choice behavior. This suggests consideration of younger and poor population in the process of introducing and/or planning public modes.

Table 2 Estimation results of all models

Variables	MNL		NL-1		NL-2	
	Estimates	t-value	Estimates	t-value	Estimates	t-value
Car Constant	3.517	8.993	0.675	1.786	0.461	1.449
Taxi Constant	2.592	16.830	1.083	4.463	0.722	6.061
Bus Constant	2.527	12.583	-0.813	-0.479	-1.018	-0.826
Age1 (0-20)	-0.517	-1.517	-0.519	-1.416	-0.350	-1.130
Age2 (20-60)	-0.484	-1.393	-0.453	-1.214	-0.297	-0.941
Car Ownership	1.049	8.388	1.085	4.915	1.031	8.863
Income1 (0-10,000)	-0.568	-2.787	-0.627	-2.493	-0.595	-3.089
Income2 (10,000-30,000)	-0.563	-4.123	-0.613	-3.523	-0.554	-4.359
Income3 (30,000-50,000)	-0.222	-1.550	-0.230	-1.497	-0.168	-1.268
Travel Cost	-0.002	-1.590	-0.003	-1.105	-0.002	-0.819
Travel Time (In Vehicle)	-0.009	-3.123	-0.010	-3.281	-0.010	-4.012
Logsum Private		NA	1.101	4.438	NA	NA
Logsum Public		NA	0.857	1.130	0.738	1.431
Rho-Square		0.184		0.184		-0.014
Adjusted Rho-Square		0.179		0.179		-0.019

After obtaining the results of the MNL model, the authors thought that there might be some common and shared attributes between the public modes (taxi and bus) and private modes (car and motorcycle) hence, the first nested model (NL-1) was selected. In this model we grouped (nested) public transport and private transport to see if there are share attributes. Once the model was run, the logsum of private mode

had a coefficient of 1.101 which suggest weak bond between car and motorcycle, though, the logsum value for public mode was significant at 0.857. Later the second nest was chosen (NL-2) where only public modes were grouped together while private modes were left alone. The estimations confirmed a stronger bond between public modes. The result of estimation for all the models can be seen in Table 2.

(3) Analysis of supply (the drivers)

For having a clear evaluation of the paratransit system of Kandahar city, attempts were made to study the supply side i.e. drivers as well. Based on the results most of the paratransit drivers in Kandahar city are aged from 20-50 years (92.5%). The majority of them are married (89.5%) and a big percentage (62%) are illiterate. However, some of them have very basic knowledge which is limited to reading and writing alone. One interesting point is that 20% of the drivers confessed that they do not own any type of driving license and are still driving freely. Though in reality this number is way bigger as most of the drivers are afraid and will give a false statement by saying they have a driving license. On the other hand, the income level of the drivers is much lower compared to other normal residents of the city. Based on the findings, 54% of the drivers have a monthly income of 5,000-10,000 which can be categorized as low income in the context of Afghanistan though the drivers are working hard as almost 80% of the drivers are driving 40km or higher per day (Figure 4).

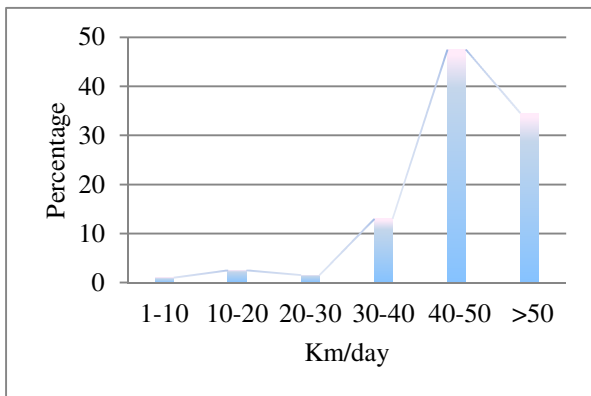


Fig.4 Daily mileage of drivers

In response of a question which asked the drivers why they chose this job, 91% stated that they had no other choices.

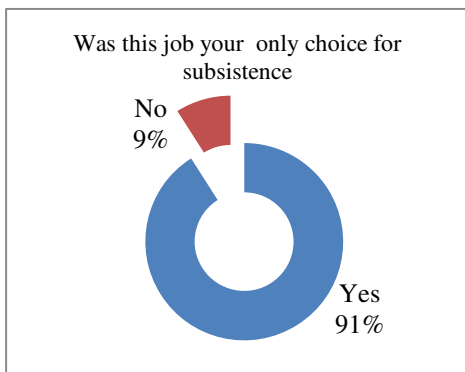


Fig.5 Reason of choosing this job

(a) Results of binary logit model

In order to study and estimate the supply of drivers for the new bus system, we ran a binary logit model for the questions asking the drivers about whether they want to change their jobs, and if they want, do they want to be bus drivers in the future. The results show some level of significance which means most of the drivers are likely to join as bus drivers. Still, these drivers may not be sufficient for running entire system of bus in the future. Nevertheless, other residents of Kandahar city who are jobless and/or not happy from their current jobs may show eagerness in becoming bus drivers.

Table 2 Binary model estimation results

Variables	Estimates	t-value
Age1 (16-30)	2.103	2.865
Age2 (30-60)	1.573	2.218
Income1 (0-10,000)	-0.183	-0.262
Income2 (10,000-30,000)	-0.722	-1.408
Taxi Ownership	0.493	0.995
Change Job	1.091	3.426
Likeratio		0.062

3. CONCLUSION

This study focused on supply and demand aspects of the currently available paratransit system of Kandahar city as well as the future modes. The results of the RP survey showed that very few people use the current paratransit system for their daily trips. However, the SP results confirm that some people particularly female generation is interested in a regular bus system in future. Moreover, the results of MNL and NL suggested that residents of Kandahar city are more concerned about travel time. In other words, speed, waiting time, number of stops/stations and the distance between the stops will play a vital role in terms of ridership. Additionally, the coefficients of age and income are also significant suggesting the importance of these factors in planning of the bus system.

On the other hand, the supply side i.e the drivers of public modes in Kandahar city are not really satisfied from their jobs and income levels. Furthermore, their income is much lower compared to incomes of other residents working the same amount or even less. This has made the drivers to think about changing their jobs and show eagerness in becoming bus drivers in future. Though these drivers may not suffice the whole demand of bus drivers and hiring other jobless people may be required.

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