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GEOGRAPHIC INFORMATION SYSTEM (GIS) BASED ANALYSIS OF URBAN TRIP DISTRIBUTION FORECAST OF BIDA TOWN

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ABSTRACT

The purpose of the research was to study the urban home trips distribution using Geographic Information System (GIS) tool based on the mobility surveys conducted in Bida town in 2007.The pattern of trip distribution is a basic tool necessary for plan formation and implementation in the transportation system. The problem of transportation within a township can only be resolved when proper and effective information on the transportation is available. Bida Township will contribute immensely to the scare knowledge if base available for transportation planning. A mobility survey was conducted with a structured questionnaire designed and administered at various defined destination; questionnaires were contained in trip count, (generation and attraction) at each zones. The town is divided into four (4) zones: Zone 1(include the institutional areas consist of Federal Polytechnic and College of Administration & Business Study (CABS),Zone 2(include the Wadata/Local Government Area; the administrative area of Bida town),Zone 3(Esso area; the outer commercial Zone), and Zone 4(the Federal Medical Centre/School of Nurse Area; the zone consist of public institutions).The trip production and the relative attractiveness for day (Monday and Friday; the peak hours period) in December 2009 are generated. The inter-zonal travel times were calculated using the gravity model. The research revealed that landuse is a determinants factor in transportation distribution in urban centers. The analysis reveal that there exists a high level of attractiveness in Esso FMC/School of Nursing and Bida Poly/Cabs respectively, with Esso haven the highest level of attraction of 332.51(50.34%) been a commercial landuses; followed by institution

and public landuses.

Keywords: *Origin-Destination Travel Survey, GIS, Urban Transportation, Travel Demand Model.*

INTRODUCTION

Population increase and urbanization tend to increase the need for transportation especially in urban areas when mobility is needed for a variety of socio – economic reason. Transportation is the cornerstone of civilization. Its demand is a derived one because it depends on the demand for the commodities carried or the benefit of personal travel and each travel is unique in time and space. Transportation influence the location of various activities in urban areas and landuse also influence the development of transportation network. Thus for example, any change in landuse according to Ogbazi (1992) may lead to increased trip generation with resultant greater traffic. Trip generation affects the route way, the vehicle and the terminal facilities and thus necessitating the provision of more transport facilities. Most of the trips in urban areas are journey to work made on road. From the morning hours people from all works of life trip out almost at the same time causing traffic congestion. A similar scenario occurs in the evening peak period journey to home period.

Travel demand forecasting is the most important phase in the urban transportation planning process. The approach of disaggregate travel demand modeling of travel behaviour (especially choice of mode and choice of destination), identifies the individual person or household as the appropriate unit for modeling travelling behaviour (Chadwick, 1987). The purpose of travel demand forecasting is to predict the travel demands on the roads in order to estimate the likely transportation consequences of transportation alternatives (including a do-nothing alternative) that are being considered for implementation. Usually, travel demand forecasting is performed using a 4-step sequential model described as follows: Trip Generation: Should I make a trip? Trip Distribution: Where should I go?, Modal Choice: What mode of transportation should I use? And Trip Assignment: Which route in the network should I take?

Nowadays urban transportation system analysis and modeling requires several know-how and knowledge for responding to actual

challenges and issues (energy, environment, urban sprawl, demographics, congestion, infrastructure planning and rehabilitation). Amongst specialized tools used for medium and long term studies, GIS visualization tools are becoming prominent. Geographic Information System can be applied to any service that is dependent on network like water supply, power supply, sewage etc. so it could be of good help for Transportation Engineering and Planning also. When so many parameters are to be connected with transportation network like travel time, speed, road resistance, turning movement etc. for such big network GIS proves itself as an efficient tool for solving such a network problems quickly and with a greater precision (Mukti Advani, 2005). While there is growing level of utilization of GIS in transportation (GIS T), a comprehensive GIS T requires that all network representation data can be cross referenced to a single base map. Transportation model network is an extreme example of spatial differences with underlying geography. However, for transportation planning purpose, the depiction of the model network on real – streets has a number of merits and is being requested by more agencies who have begin to use GIS for transportation planning (Sutton, 1995).

In Bida town today, population is growing at an unprecedented rate and the decision to travel from one part of the town to another is on the increase. As such, trips are generated from a particular zone and distributed to several other zones. However, the nature and frequency of trips generated and distributed is unknown in the town which is veritable information for effective transportation planning. There are a number of methods used to predict trip distribution but the gravity model was used in this research work because it stressed the importance of specific values of trip attraction and resistance and also recognized the influence of trip purpose on travel patterns. Most importantly, it posses the added advantage over the growth factor methods in that changes in the future landuse pattern could now be accounted for and that improvement of existing transportation facilities could be taken into consideration in the travel resistance factor (Bruton, 1985). GIS was used to plot the result of traffic forecast on real street maps.

CONCEPT OF TRIP GENERATION, TRIP DISTRIBUTION AND TRAVEL DEMAND MODELS

a) Trip Generation:

The main function of trip generation is to process and estimate the total number of trips generated and attracted by each area unit (zone) in conjunction with landuse and the socio – economic characteristics of each zone. There three approaches commonly used in the trip generation analysis: regression analysis, trip rate analysis and cross – classification analysis (Oyedepo *et al*, 2009). Trip generation models are found to be accurate if separate models are used based on trip purpose. The trips can be classified based on the purpose of the journey as trips for work, trips for education, trips for shopping, trips for recreation and other trips. Among these the work and education trip are often referred as mandatory trips and the rest as discretionary trips (Tom *et al*, 2007).

b) Trip Distribution

The objective of a trip distribution model is to determine the total number of trips between all pairs of zones *i* and *j*, where *i* is the trip-producing zone and *j* is the trip-attracting zone of the pair. The rationale of trip distribution is as follows: all trip-attracting zones *j* in the region are in competition with each other to attract trips produced by each zone *i*. Everything else being equal, more trips will be attracted by zones that have higher levels of "attractiveness." Linear programming formulation, regression models, Growth factor model, intervening opportunity model and gravity – type model (Oyedepo *et al*, 2009). The gravity model employs two relationships, the first of which is indirect. The shorter the travel time to the destination zone, the greater the number trips will be distributed to it from the origin zone. The second relationship is a direct one. The more attraction there are in a destination zone, the more trips will be distributed to it from the origin zone.

Relative distribution rates express the effect that spatial separation has on trip interchange. These factors are measure of the impedance to inter zonal travel due to the separation between zones. In effect, they measure the probability of trip making at each one – minute increment of travel (Tom *et al*, 2007).

c) Travel Demand Models

Travel demand models are developed to simulate actual patterns and existing demand conditions. Networks are coded using current roadway inventory files containing data for each roadway within the network. Travel demand is generated using economic data such as household size, automobile availability, employment data. Once the existing conditions are evaluated and adjusted to satisfactory replicate actual travel pattern and roadway volumes, the model inputs are then altered to project future year conditions. Using these inputs, the model is able to determine capacity limitations relative to the current roadway system (Ogunsanya 2003). Once these deficiencies are identified, potential improvements are evaluated by rerunning the model with an "improved" or modified transportation system. A range of different street networks and different landuse pattern are tested in this way.

THE STUDY AREA

Location

Bida lies at 9° 06'N and 6°01'E on the Nupe basin formation which consists of plains with iron stone capped mesas. The scenery is fairly uniform since lithology and relief are not greatly variable. An import important feature of the area is the existence of large area of fadama. The northern edge of the town consists of a broken off Plateaus from the foot of two flat streams and Munsa streams with the third stream Landzun, which flows across the heart of the town. The importance of these rivers provide good irrigation opportunities for the inhabitants has both economic and social importance. Bida town is bounded by Pichi in the west, Baddegi in the east, Gbaji in the north and Doko in the south. The town is in the north east of Federal Capital Territory Abuja which is about 89 km from Bida.

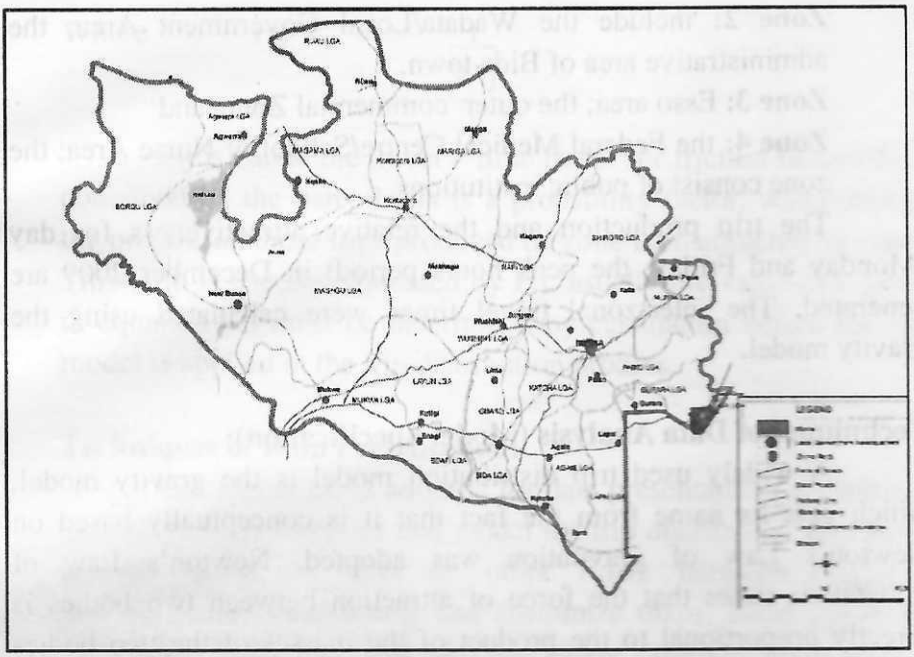

Fig. 1.1: Map of Niger State Showing the Location of Bida

RESEARCH METHODOLOGY:

Data Collection Techniques

Various methods of data collection were used in the course of this research. This includes cross sectional data, the aim of this is to generate current data for this study, it must be pointed out that emphasis placed on cross sectional data often depend on the state of growth and development of the subject areas, as well as the rate of changes in government policies, technology and accessibility to resources input.

In generating across-sectional data, primary and secondary data's and personal experience were also used to obtain information for this research. A mobility survey was conducted with a structured questionnaire designed and administered at various defined destination; questionnaires were contained in trip count, (generation and attraction) at each zones. The town is divided into four (4) zones:

- **Zone 1:** include the institutional areas consist of Federal Polytechnic and College of Administration & Business Study (CABS),

- **Zone 2:** include the Wadata/Local Government Area administrative area of Bida town,
- **Zone 3:** Esso area; the outer commercial Zone, and
- **Zone 4:** the Federal Medical Centre/School of Nurse Area zone consist of public institutions.

The trip production and the relative attractiveness for (Monday and Friday; the peak hours period) in December 200 generated. The inter-zonal travel times were calculated using gravity model.

Techniques of Data Analysis (Model Specification):

A widely used trip distribution model is the gravity which gets its name from the fact that it is conceptually Newton's Law of gravitation was adopted. Newton's gravitation states that the force of attraction between two directly proportional to the product of the masses of the and inversely proportional to the square of the distance It can be described by the following equation:

$$F = K \frac{m1m2}{r^2} \quad \text{----------}$$

The variation of the Newton's Law of gravitation distribution takes the following form:

$$Tij = K \frac{PiAj}{Wij^c} \quad \text{----------}$$

Tij is the total number of trips between Zone i and are the total trip productions for zone I and attraction the relative attractiveness of zone j. for a given constant value, Wijc is the travel impedance, which either the travel time or the travel distance (in the by travel time). Rewriting equation (4) in a form the trip productions and probability factor, results equation (5).

$$Tij = P \frac{AiFij}{\sum x^A x Fix} \quad \text{----------}$$

Where $Fij = \frac{1}{Wij^c}$

Fij is called the travel – time factor (or friction factor) the term contained by the parenthesis is a probability factor, which represents the proportion those trips produced by zone I am attracted by zone j. This term is usually expressed by Pij, usually the value of exponent c in equation (2) must be determined by calculation before the gravity model is applied in the trip distribution process.

Techniques of Data Presentation:

GIS technique is adopted for data presentation.GIS software is us used to fully integrate and model the trip distribution to predict the spatial pattern of trips or other flows between origins and destinations.GIS can create and customize maps, build and maintain geographic data sets, and perform many different types of spatial analysis to show strip charts that depict volume of traffic and their variation along routes. Sophisticated GIS features such as polygon overlay, geocoding, and Route system maps that show overlapping routes side-by-side for greater visibility were used for presentation.

DATA ANALYSIS AND DISCUSSION OF RESULT

Trip Production and Attraction in Bida Township

The town is divided into four (4) zones as shown in figure 5.1 Zone 1 is an institutional setting consist of Educational Institution (Federal Polytechnic and College of Administration & Business Study [CABS]), Zone 2, Wadata/Local Government Area is an administrative site, Zone 3, Esso is a commercial Zone and Zone 4, Federal Medical Centre/School of Nurse Zone is a public institution zone.

The trip production and the relative attractiveness for a day (Monday) in December 2007 are generated and illustrated in table 5.1. The inter-zonal travel times are found in table 5.2. A calibration of the gravity model has also found that C in the gravity equation (3) equals 2.0.

Table 5.1: Trip Production Pí and Attraction Aí for the four Zone Network

S/N	Zone	Production	Attraction
1	Bida Poly/CABS	20	1230
2	Wada/LG Sec	30	320
3	Esso Zungeru Rd	600	900
4	FMC/NSSN	10	400
Total		**650**	**2850**

Source: Authors field Analysis, 2009

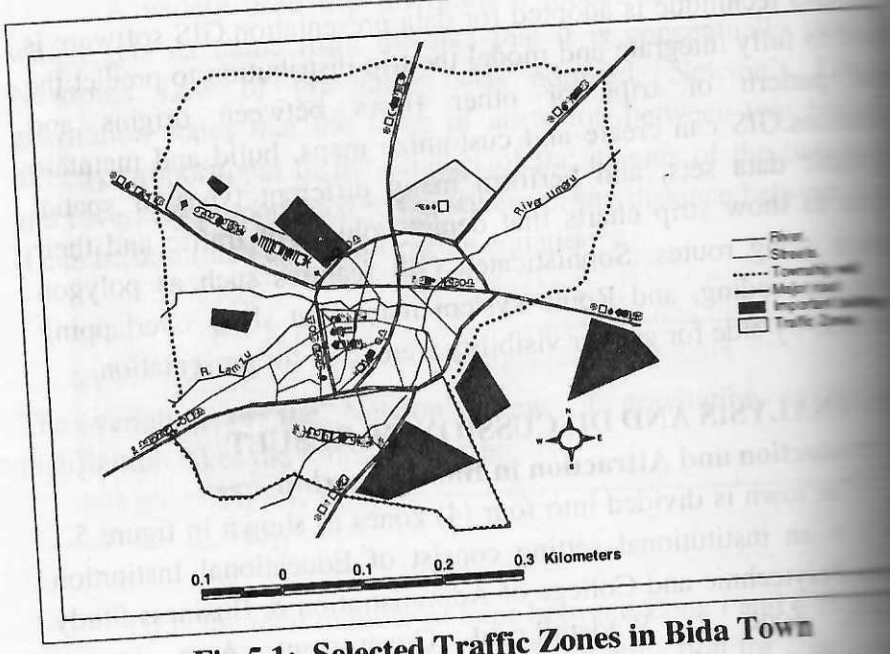

Fig.5.1: Selected Traffic Zones in Bida Town

Table5.2: Travel Time W2j between Zone S and Zone J

i/j	1	2	3
1	5	10	10
2	10	5	10
3	10	10	5
4	5	5	5

Source: Authors field Analysis, 2009

To Estimate the Interchange Trips Between Zones

To estimate trip interchange between zones;

(i) For the origin í = 1 (Bida Poly/CABS), the trip production Pí = 20. Base on equation:

$$Tij = Pí \left(\frac{^{A}j\ F_j}{\sum^{A}2\ Fij}\right) \text{ ---------- (3)}$$

Where $Fij = \frac{1\ 1}{W\ ij}$

And table 4.1, the friction factor Fíj was be calculated as follows:

$Fíj = \frac{1}{Wíj^2} = \frac{1\ 1}{5^2} =$ **0.04** $Fíj = \frac{1}{W12^2} = \frac{1\ 1}{10^2} =$ **0.01**

$F13 = \frac{1}{W13^2} = \frac{1\ 1}{10^2} =$ **0.01** $F14 = \frac{1}{W14^2} = \frac{1\ 1}{5^2} =$ **0.04**

The interchange trips between Zone 1 (Bida Poly/CABS) and others, Wadata/LG Secretariat, Esso and FMC/School of Nurse is calculated base on the equation (3). To simplify the calculation process, the following table 5.3 is used to perform the calculation.

Table 5.3: Interchange Trip between Zonal and other Zones

J	Aj	Fij	Aj Fij	Pij	Tij
Bida Poly/CABS	1230	0.04	49.2	0.636	12.72
Wadata/LG Secretariat	320	0.01	3.2	0.041	0.82
Esso	900	0.01	9	0.016	2.32
FMC/School Nurse	400	0.04	16	0.207	4.14
			Efij =77.4	**1.00**	

Source: Authors field Analysis, 2009

For the origin í = 2, the trip production P2 = 30. A similar calculation table to the above is used to calculate the interchange trips between Zone 2 (Wadata/LG Secretariat) and others Zone (Table 5.4).

Table 5.4: Interchange Trip between Zone 2 and Other Zones

J	Aj	Fij	Aj Fij	Pij	Tij
Bida Poly/CABS	1230	0.01	12	0.241	
Wadata/LG Secretariat	320	0.04	12.8	0.257	
Esso	900	0.01	9	0.181	
FMC/School Nurse	400	0.04	16	0.321	
			∑ = 49.8	**1.00**	

Source: Authors field Analysis, 2009.

For the origin í = 3 (Esso), the trip production P3 = 10. A similar calculation table to the above is used to calculate the interchange trips (table 4.5) between zone 3 (Esso) and other zones (Bida Poly/CABS, Wadata/LG Secretariat and FMC/School of Nurse).

Table 5.5: Interchange Trip between Zone 3 and Other Zones

J	Aj	Fij	Aj Fij	Pij
Bida Poly/CABS	1230	0.01	12	0.179
Wadata/L.G Secretariat	320	0.01	3.2	0.048
Esso	900	0.04	36	0.536
FMC/School Nurse	400	0.04	16	0.238
			∑ = 67.2	**1.00**

Source: Authors field Analysis, 2009

For the origin í = 4 (FMC/School of Nurse), the trip production P3 = 10. A similar calculation table to the above is used to calculate the interchange trips (Table 5.6) between zone 4 (FMC/School of Nurse) and other zones (Bida Poly/CABS, Esso and Wadata/LG Secretariat).

Table 5.6: Interchange Trip between Zone 4 and Other Zones

J	Aj	Fij	Aj Fij	Pij	Tij
Bida Poly/CABS	1230	0.04	49.2	0.432	4.32
Wadata/LG Secretariat	320	0.04	12.8	0.112	1.12
Esso	900	0.04	36	0.316	3.16
FMC/School Nurse	400	0.04	16	0.140	1.4
			$\sum$ = 114	**1.00**	

Source: Authors field Analysis, 2009

Haven't know, the various interchange between the zones, the final interchange trips can be summarize into the following table 5.7.

Table 5.7: Summary of interchange between zones

I \ J	Bida Poly/ CABS	Wadata /LG Secre-tariat	Esso/ Zungeru Rd	FMC /Sch. of Nurse	Total trip production
Bida Poly/CABS	12.72	0.82	2.32	4.14	19.262
Wadata/LG Secretariat	7.23	7.71	5.43	9.63	30(4.55%)
Esso	107.4	28.8	321.6	142.8	600.6(91.02%)
FMC/School Nurse	4.32	1.12	3.16	1.4	10 (14.31%)
Total trip attraction (Ai)	**131.67 (19.93 %)**	**38.45 (5.82%)**	**352.51 (50.34 %)**	**157.97 (23.97 %)**	

Source: Authors field Analysis, 2009

RESULT DISCUSSION:

Interchange between Zones:

The researcher analysis have shown that there is high level of trip interchange (table 5.7) within Esso Zone been the major

commercial outfit or CBD. The result had shown that over 50.34% (332.51) trips are made within Esso Commercial Zone. Also there is high trip interchange between Esso and FMC/School of Nurse, as well as between Esso and Bida Poly/CABS. The research result reveals that 142.8 of the total trip interchange occurred between Esso and FMC/School of Nurse. This followed by Federal Polytechnic Bida with 107.4 trip interchange. The reason for this may due to commercial function of Esso (also first point of call when arrived Bida town) and pulling factor of the two major public institutions (i.e. FMC/School of Nurse and Federal Polytechnic Bida). Also low level of trip interchange was recorded between FMC/School of Nurse Zone and Wadata/LG Secretariat zone as well as within FMC/School zone (see table 5.7).

The Total Trip Attractions for Zones 1, 2, 3 and 4.

The objective of trip distribution model is to determine the total number of trips between all pairs of selected zones i and j, where i is the trip – producing zones and j is the trip attracting zones of the pair. The rationale of trip distribution is as follows; all trip-attracting zones j in the town are in competition with each other to attract trips produced by each zone i. everything else being equal, more trips will be attracted by zones that have higher levels of "attractiveness".

However, research result (table 5.7) had shown that there exist a high level of attractiveness in Esso, FMC/School of Nurse, and respectively. Esso have the highest level of attraction of 303.9 (50.64%) of all trips, followed by FMC/School of Nurse with total attraction of 157.97 (23.91%) trip and Bida Poly with 131.67 (19.59%) trip attractions. The high level of attraction in these zones coincides with the nature of activities in this zone and population there should (pulling population) (see fig. 5.2). The result also had shown that 600.6 total trip attractions equal the total trip production from Zone (the commercial learnt of Bida Township).

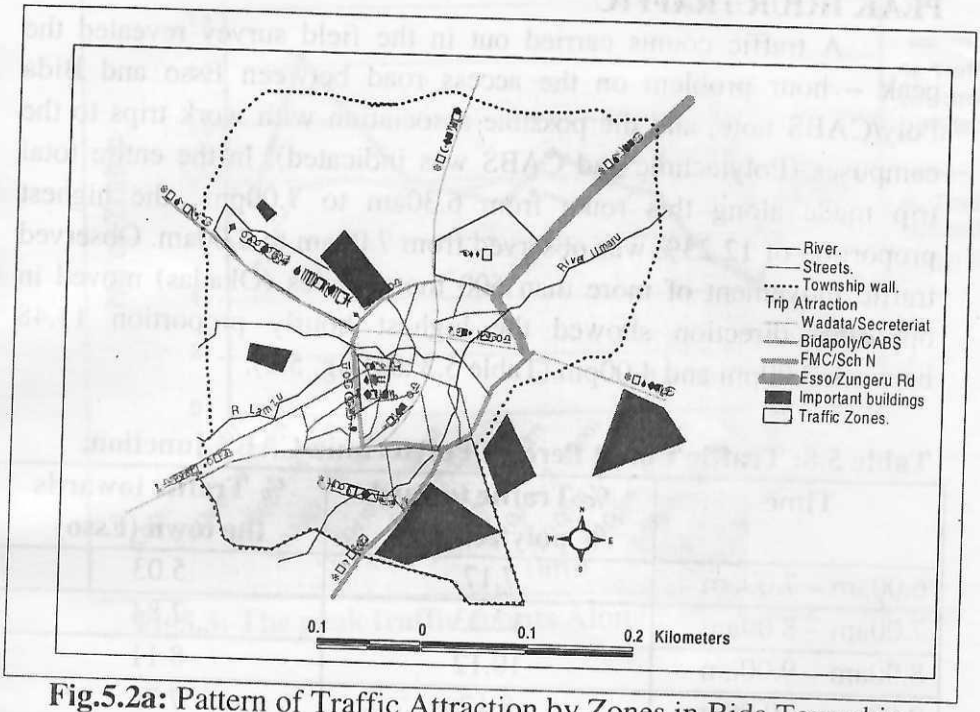

Fig.5.2a: Pattern of Traffic Attraction by Zones in Bida Township

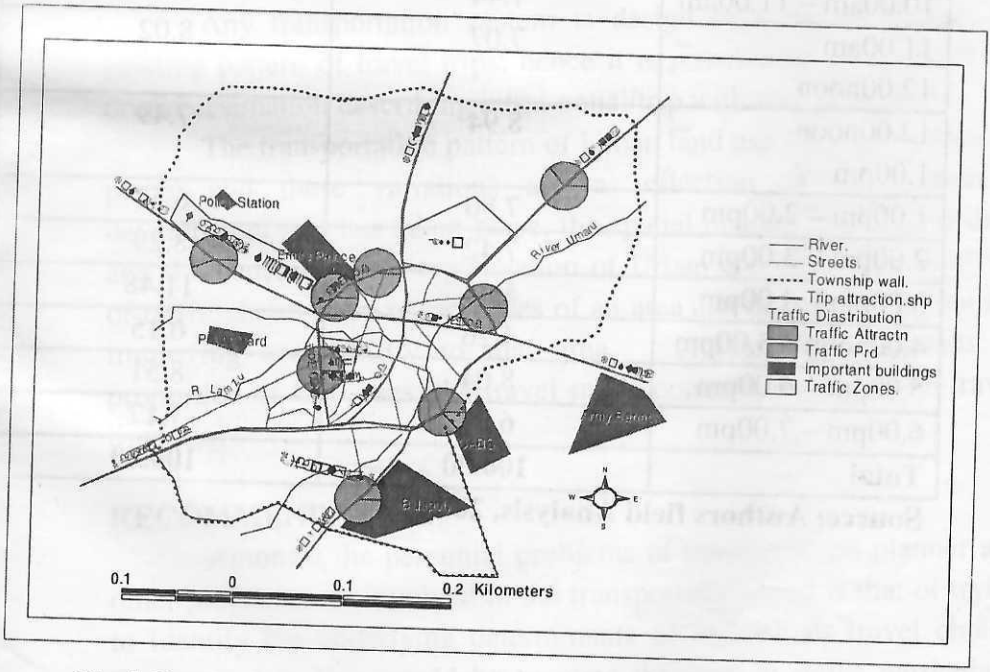

Fig.5.2b: Traffic Attraction and Production by Zones in Bida Township

PEAK HOUR TRAFFIC

A traffic counts carried out in the field survey revealed the peak – hour problem on the access road between Esso and Bida Poly/CABS note, and the possible association with work trips to the campuses (Polytechnic and CABS was indicated). In the entire total trip made along this route from 6.30am to 7.00pm., the highest proportion of 12.23% was observed from 7.00am to 8.00am. Observed traffic movement of more than 500 motorcycles (Okadas) moved in opposites direction showed the highest hourly proportion 11.48 between 3.00pm and 4.00pm (Table 5.3 and fig. 5.8).

Table 5.8: Traffic Count Percent Polytechnic/CABS Junction.

Time	% Traffic toward polytechnic	% Traffic towards the town (Esso)
6.00am – 7.00am	7.17	5.03
7.00am – 8.00am	12.23	7.84
8.00am – 9.00am	10.12	8.11
9.00am – 10.00am	8.17	7.76
10.00am – 11.00am	7.44	7.58
11.00am – 12.00noon	7.07	8.02
12.00noon – 1.00pm	8.94	7.49
1.00pm – 2.00pm	7.80	6.57
2.00pm – 3.00pm	7.42	8.29
3.00pm – 4.00pm	5.31	11.48
4.00noon – 5.00pm	4.26	6.15
5.00pm – 6.00pm	8.04	8.51
6.00pm – 7.00pm	6.03	7.17
Total	**100.00**	**100.00**

Source: Authors field Analysis, 2009

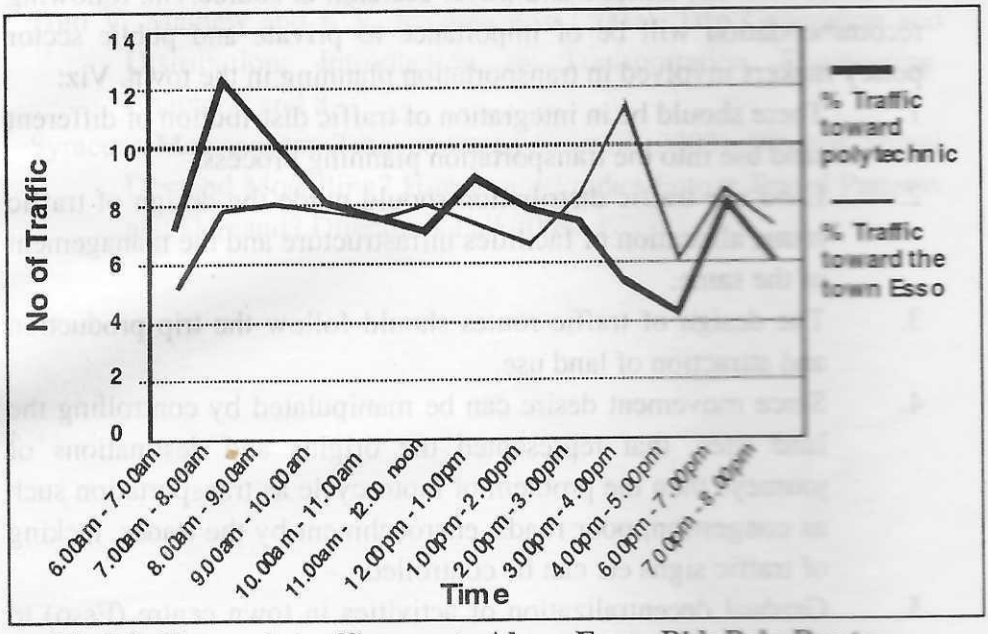

Fig5.3: The peak traffic counts Along Esso –BidaPoly Route

CONCLUSION AND PLANNING IMPLICATION

Any transportation system is design to serve or change an existing pattern of travel trips; hence it is possible to derive from an origin destination describing intral-zonal/trip within an urban area.

The transportation pattern of Urban land use vary from place to place, and these variations are a reflection of the historical development that has taken place, the spatial distribution of land uses and the general spatial organization of Urban activities. The analysis of traffic distribution of land uses of an area can be a working tool for improving accessibility to that area. Accessibility responds to proportion of land uses, the travel mode common to it and the travel time.

RECOMMENDATION

Amongst the perennial problems of transportation planner and other professionals involved in the transportation filed is that of trying to identify the underlying determinants of individuals travel choice. To succeed in this would be to open the way to move particularly acceptable plans for traffic restrained by applying measures likely to

influence relevant attitude and travel decision at source.The recommendation will be of importance to private and public policy makers involved in transportation planning in the town.

1. There should be in integration of traffic distribution of land use into the transportation planning process.
2. Land use traffic distribution should guide the design route, allocation of facilities infrastructure and the of the same.
3. The design of traffic routes should follow the trip and attraction of land use.
4. Since movement desire can be manipulated by land uses, that represented the origins and journeys then the problem of motorcycle as as congestion, poor roads, encroachment by the of traffic signs etc can be controlled.
5. Gradual decentralization of activities in town centre the peripheral regions which is only possible decentralization of land uses.

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