

*Full Length Research Paper*

# **Modelling inter-urban trip flow pattern of selected cities in Niger State, Nigeria**

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**Inter-urban travel forms one of the main spatial and economic features of any nation's economic landscape. Understanding and forecasting inter-urban movement is a crucial input for urban and regional transportation planning. This study therefore was carried out to develop trip generation model of selected cities in Niger State. Questionnaire survey was carried in three main urban centres in the state namely; Minna, Bida and Suleja. Four (400) copies of questionnaires were administered at the three major public motor parks where travelers usually board vehicles for inter-city travels Niger state. Using multiple stepwise regression model analysis, six independent variables namely; travel distance (TD), travel time (TT), population (PP), public institution (PI) and fare charged (FC) were regressed against the dependent variable (Y) which is inter urban travel flow (ITF). However, only 2 independent variables; that is population (PP) and fare charged (FC) were good and significant for explaining the variation in the flow of inter urban trips in the state. Two variables record  $R^2$  of 1.00 which implies 100% contribution to explanation of the variation in the inter-urban travel in Niger State. The study also discovered that Minna-Suleja route constitutes the heaviest traffic corridors in the state. In view of these findings, it was recommended that adequate public transport provision should be made to meet inter urban travel needs within the state by NSTA and a more comprehensive regional transportation planning for the entire state is recommended to cover other important towns that could not be covered in this study.**

**Key words:** Inter urban, travel, pattern, flow, generation, attraction.

## **INTRODUCTION**

Transport has been an important component of man's activities in space. Man's ability to move himself and his materials from one point to another on the earth significantly influences his life and his environment (Ahmed, 2013). Transportation therefore bridges the gap between people and resources in both space and time. One of the ways by which man organizes the space

around him is through formation of settlement and the use of transportation as a tool to bringing orderliness into the settlement. Ogunsanya (2002) emphasized on the inevitability of transportation in the city and related basic necessities of life, and stressed that man's basic need of food, clothing and shelter could be hardly achieved without transportation. In most countries, including

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developing countries, cities are the major source of economic growth. The transport sector is therefore an important component of the economy and a common tool used for development even at a global level where economic opportunities have been increasingly related to the mobility of people and freight, including information and communication technologies (Rodrigue, 2020).

At regional level, transport also promotes spatial, social and economic interaction between one settlement and the others. The provision of efficient and effective transport system is a precondition for spatial and economic integration among various communities (Ogunsanya, 2002; Ojekunle, 2014). It has also been established that the pattern of urban movements is influenced by the size and density of settlement, topography, length of journey, income and household characteristics. It is also emphasized that demand for transport and travel intensity tend to increase sharply with the size of a city especially when the center or major areas of activity increase correspondingly in term of both area and employment (Ojekunle and Owoye, 2018; Ojekunle et al., 2019).

The problems of inter urban travel in Niger state are not only many but are also very complex; which include poor road infrastructure, high cost of transportation, poor environmental condition, insufficient right of way, security challenges, inadequate terminal facilities to cope with the demand and poor condition of vehicles. The problem of inter-urban linkages within Niger state has existed for a long time and so Niger state has been known for its bad road network (Ojekunle et al., 2019).

The knowledge of travel demand for public transport service in Niger state therefore, is key to a successful transport system transformation. The efforts of the government to expand road capacity to accommodate the growing traffic are usually hindered by lack of sufficient and reliable data as well as inadequate planning tools and inputs. The lack of adequate information has severally led to over or underestimating future traffic and over or underinvestment in the provision of transport facilities and infrastructure (Ojekunle, 2014). A better understanding of inter urban travel demand will no doubt help the planners and policy makers to make effective policy decision on transport planning, investment and operation.

The lack of reliable information on inters urban travel in Niger state makes effective and efficient inter-urban transportation planning difficult. A study of inter-urban travel demand pattern in addition to providing specific information on the relative importance of causal factors (such as, trip frequency, route distance, journey time, and fare) in determining demand travel in Niger state, will therefore serve as a basis for estimating future inter-urban trip generation in Niger State.

Furthermore, these factors are expected to be quantified and their level of contribution to our understanding of inter urban travel demand will be

determined. Inter-urban travel demand models in Nigeria have shortcomings in terms of quantification of their variables which this research seeks to address, in so doing we contribute to both fundamental understanding of travel demand especially in Niger state and the practical need to predict how demand will respond to a range of future scenarios. It is in the light of this, that this study attempts to model inter urban trip generation in Niger State in order to be able to establish a basis for estimating the future inter-urban trip generation.

## LITERATURE REVIEW

### Travel demand modeling

Intercity travel behavior is different from urban travel behavior in certain aspects, such as travel frequency. However, it still follows the general four-step model for urban travel behavior: trip generation, trip distribution, mode choice, and trip assignment. Intercity travel decision making is typically assumed to consist of trip generation, destination choice, mode choice, and route choice (Chatterjee and Venigalla, 2004)

When used for intercity travel, the model consists of two sequential steps that predict intercity travel by mode. The first step forecasts the total intercity travel volume for city pairs. The second step distributes the volume via a logit model. Typically, the number of trips is formulated as a function of the socio-economic characteristics of city pairs and composite measures of the level of service. Today these models are still in applications such as forecasting high-speed rail ridership (Brand et al., 1992). Conventional travel demand models separate the demand functions into four steps.

### Trip generation models

Trip generation is defined as the number of individual trips generated in a given period of time. Traditionally, in travel demand modeling, trip generation is the first component that provides the possibility for the next steps, such as destination choice and mode choice. In the context of urban travel, a trip can be home-based or non-home-based. In practice, according to de Dios and Willumse (2011), it is also classified by purpose, such as trips to work, trips to school or college, shopping trips, social and recreational trips and other trips. Alternatively, the trips can be classified by person type based on income level, car ownership, household size and structure, which is often used as the model segmentation base. In an intercity travel context, a trip is usually categorized as a business trip or nonbusiness trip. It also can be further classified as business, combined business/pleasure, convention, conference or seminar, visiting relative or friends, rest or relaxation (the 1995 American Travel Survey). Trip generation analysis

requires identification of the factors that affect trip generation. Often, the variables taken into account are characteristics of the traveler, and personal trip attraction (de Dios and Willumse, 2011), as well as the attributes of alternatives. The characteristics of travelers include household income, car ownership, household structure, and household size. The personal trip attraction factors include the destination's socioeconomic, industrial, or residential context.

### **Spatial factors of inter-urban trip generation**

There are many empirical studies that have examined the spatial factors on inter urban trip generation. According to Kain and Fauth (1977) inter urban travel demand is affected by spatial factors. They had considered urban development as measured by the population density in each zone and the socioeconomic characteristics of the households and the location of their jobs and residences as strong factors to explain household modal choice. Dargay and Hanly (2002) have also highlighted the need to consider the relationship between transport and the use of space. According to Ojekunle and Owoeye (2018), travel decisions are influenced by the density of buildings and the type of activity. Button et al. (1993) have demonstrated that there is a positive relationship between car ownership rates and the level of urbanization. But this relationship applies only up to a point. Beyond this point, the infrastructure becomes so saturated that the higher the urban density the more car use, car ownership rates, number of trips and energy consumption are reduced (Camagni et al., 2002). This would lead to congestion and its attendant adverse effects. Paulley et al. (2006) have shown that demand for bus transport depends on the residential zone. Individuals who live in rural zones with low population densities tend to be more dependent on car relying less on public transport, than those living in urban zones.

As Crane (2000) has reported, it remains difficult to identify how the use of urban space impacts on travel practices. Furthermore, Handy (1996) has shown that the urban activities mix has a negative effect on car use, while emphasizing the complexity of this finding. This complexity is also apparent when we consider the form of the city, even if a polycentric structure seems to result in lower energy consumption by traffic. This scholar shows, for example, that the larger the city the longer individuals' journeys, but the size of the city does not seem to have a direct effect on modal choice.

From the above review, there has been numerous studies on modelling inter urban trip generation and attraction particularly in developed countries. However, the need for continuous studies on the travel behaviors and search for explanation on the observable inter-urban travel generation and pattern existing in many developing countries still requires further research especially in

Nigeria. This is therefore an attempt to contribute to knowledge and underlying factors influencing inter-urban travel pattern and trip generation in Nigeria using Niger state as a case study.

### **Study area**

Niger State is a state in Central Nigeria and is the state with the largest landmass in the country with total of 76,363 km<sup>2</sup>. The state capital is Minna, and other major urban centres are Bida, Kontagora, and Suleja. It was created in 1976 along with Sokoto State, when it was carved out of the then North-Western State.

The State is named after the River Niger. Two of Nigeria's major hydroelectric power stations, the Kainji Dam and the Shiroro Dam, are located in Niger State. The famous Gurara Falls is in Niger State, and Gurara Local Government Area is named after the Gurara River, on whose course the fall is situated. Also situated the state is Kanji National Park, the largest National Park of Nigeria, which contains Kanji Lake, the Borgu Game Reserve and the Zogurma Game Reserve. Figure 1 shows the map of Niger State with locations of major urban centres.

### **The study towns in Niger state**

#### ***Minna***

Minna is the administrative Capital of Niger State, it has an estimated population of 350,000 as at 2006 (NPC, 2006). Minna is one of the fast developing urban centres in the north central Nigeria. Three homogenous residential densities of low, medium and high were recognized in Minna. These residential areas are characterized by social, economic and physical patterns. Being the administrative capital of Niger State, it attracts a lot of social and economic interactions from other major urban centres within the State and from other neighboring states in the country. Apart from being the administrative headquarters of Niger State, the City houses a Federal University of Technology, an Army formation, a College of Education, the administrative headquarters of National Examination Council (NECO) and Nigerian Airforce base. All these institutions are trip generating land uses which attract and generate trips within and outside the city.

#### ***Bida***

Bida is the third largest city in Niger State with an estimated population of 171,656 people at 2006 (NPC, 2006). Its location is peculiar because it lies on the A124 highway connecting the south and the north of Nigeria, thus making it a major transit hub. Two major Federal

Institutions: The Federal Polytechnic and the Federal Medical Centre (FMC) are situated there, and Bida is home to the only Nursing School in Niger. The Town has an area of 512 km<sup>2</sup> and it is equally bounded by Gbako local government to the North, Lavun local government to the south, and Katcha local government to the west.

### Suleja

Suleja is a city in Niger State with a population of 216,578 as at 2006 (NPC, 2006). It is sometimes confused with the nearby city of Abuja, due to its proximity, and the fact that it was originally called Abuja before the Nigerian government adopted the name from the then Emir Sulayman Barau for its new Federal Capital in 1976. It was established in the early 19th century by Mohammed Makau, the last Hausa emir of Zaria and his followers who were fleeing the Fulani jihadists engaged in the conquest of northern Nigeria.

### METHODOLOGY

The cross-sectional survey research design was adopted for the purpose of data collection. Questionnaire was designed to collect data on inter urban travel behaviour and characteristics of public transport passengers. The information collected covered the conventional distance of the trip, the frequency of the trips, the estimated journey time, the fares paid, the purpose of the trip, and the type of vehicles used. To determine the sample size, the 2006 population census figures of each of three urban centres were obtained from the National Population Commission (NPC). The population figures are: Minna has 350,000, Suleja has 215,075 and Bida has 185,000 making a total of 745, 075 (NPC 2006). For the purpose of this study, these population figures were therefore projected into 2019 at growth rate of 3.2% which gave the following figures: Minna 492,100, Suleja 302,000 and Bida 260,700 making a total of 1,054800.

Based on the above population, Yamane's (1967) formula for determining the sample size was applied to arrive at a total sample size of 400. Four hundred questionnaires were distributed to passengers at the public motor parks in Minna, Suleja and Bida to elicit the required information. A total of 186, 115 and 99 questionnaires were administered in Minna, Suleja and Bida respectively. To show spatial pattern of inter urban trip flow, a digital map of Niger State was produced with the aid of ArcGIS environment. Regression analysis model was adopted for estimating inter urban trip generation of the study area.

### RESULTS AND DISCUSSION

#### Inter urban travel pattern

Attempt is made here to analyze the flow pattern of inter urban trip generation in Niger State particularly among the three major urban centres studied. Table 1 and Figure 2 show the weekly inter urban flow of trip generation and attraction among the three towns.

From Table 1, the largest trips are generated between Minna and Suleja. More people travel from Minna to

Suleja than any other towns in Niger State. The number of trips attracted to Minna from Suleja is also higher than ones from Bida. This indicates that the level of economic and social interactions between Minna and Suleja is far higher than what is existing between Minna and Bida. Figure 2 and 3 show the spatial pattern of trip generation and attraction between the three studied towns. The flow pattern shows a heavy inter urban trips between Minna and Suleja. It also shows that more trips generated from Minna to Suleja than trips generated from Suleja to Minna. This is not unconnected with higher population concentration in Minna and Suleja. Moreover, the proximity of Suleja Town to Abuja; the Federal Capital City could be a contributing factor to the level of inter urban travel noticed between Minna and Abuja.

#### Modelling inter urban trip flow determinants

Here, the study attempt to model the determinants of inters urban travel in Niger State; six independent variables were identified as probable determinants of the observable inter urban trip flow pattern in the State. The multiple regression analysis was used here for the purpose of modelling. The multiple regression models have been used severally in the literature to estimate degree of fitness and also forecast and determine the relationship between dependent variable and a number of independent variables. It can therefore be conceptualized that there is a set of variables  $x_1, x_2, x_3, \dots, x_n$  which can be used to explain the inter urban trip flow among the urban centres in Niger State.

This can be expressed mathematically as:

$$Y = f(X_1, X_2, X_3, \dots, X_n) \quad (1)$$

As a result, the equation can be written using multiple regression equation thus;

$$Y = a + b_1x_1 + b_2x_2 + b_3x_3 + \dots + b_nx_n + e \quad (2)$$

Where the dependent variable;  $a$  = constant;  $b_1, b_2, b_3, \dots, b_n$  = the intercept;  $x_1, x_2, x_3, \dots, x_n$  = the dependent variables, and  $e$  = error term (unexplained variables)

In this study,  $Y$  which is the dependent variable is the inter urban trip flow among the three major towns of study in Niger State denoted as (ITF). The following have been identified as independent variables:

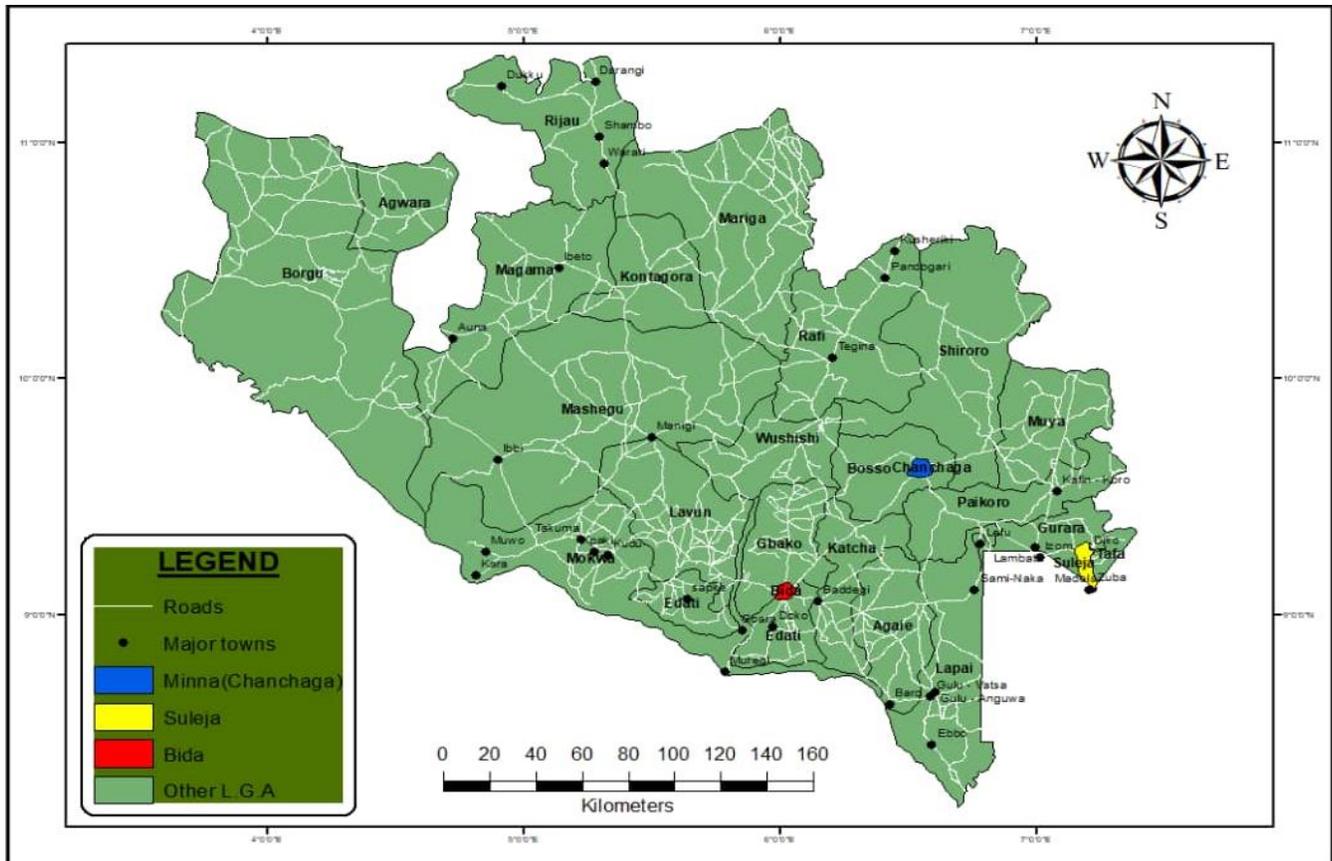
$X_1$  is the travel distance measured in kilometre denoted as (TD).

$X_2$  Travel time is measured in minutes denoted as (TT).

$X_3$  Population measured in number of people living in each town denoted as (PP)

$X_4$  Public Institution measured by the number of establishments of higher educational institutions found in each town denoted as (PI)

$X_5$  Fare charged is measured in naira (Nigerian national



**Figure 1.** Map showing selected towns in the context of Niger State.  
Source: Adapted from administrative map of Niger State (2019).

**Table 1.** Inter-urban travel generation and attraction in Niger State.

Towns	Route	Weekly inter-urban trip flow	Percentage
Minna	Minna - Suleja	5388	48.31
Suleja	Suleja - Minna	3183	28.54
Bida	Bida- Minna	2583	23.16
<b>Total</b>		<b>11154</b>	<b>100</b>

Source: Ojekunle et al. (2019)

currency) denoted as (FC)

The above variables are hereby operationalized as;

$$ITF = a + b_1TD_1 + B_2TT_2 + b_3PP_3 + B_4PI_4 + b_5FC_5 + e \quad (3)$$

However, the first step taken in modelling inters urban trip generation and attraction is to carry out correlation analysis of both dependent and independent variables. Table 2 shows the correlation matrix of both dependent and independent variables. It is revealed that all the independent variables are highly correlated with dependent variables; none of them has less than 65%

correlation coefficient. The population of each town (PP) has the highest correlation with inter urban trip flow (ITF) which implies that interactions between settlements is a function of population size., while the travel distance has the least of 66.5% correlation coefficient. The table also reveals that there is high level of multi collinearity among independent variables. The least correlation coefficient is recorded between fare charged (FC) and public institution (PI). However, in modelling trip flow and generation multi-collinearity is not considered as a problem as long as the scenario continues into the future.

Another remarkable thing one could notice from Table

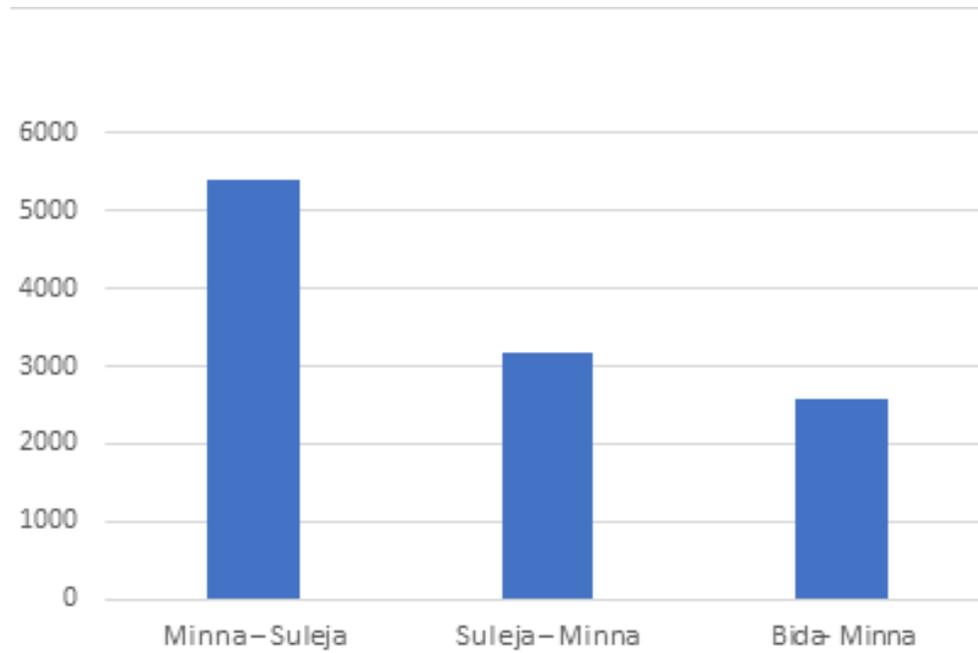


Figure 2. Inter-urban travel between towns in Niger State.

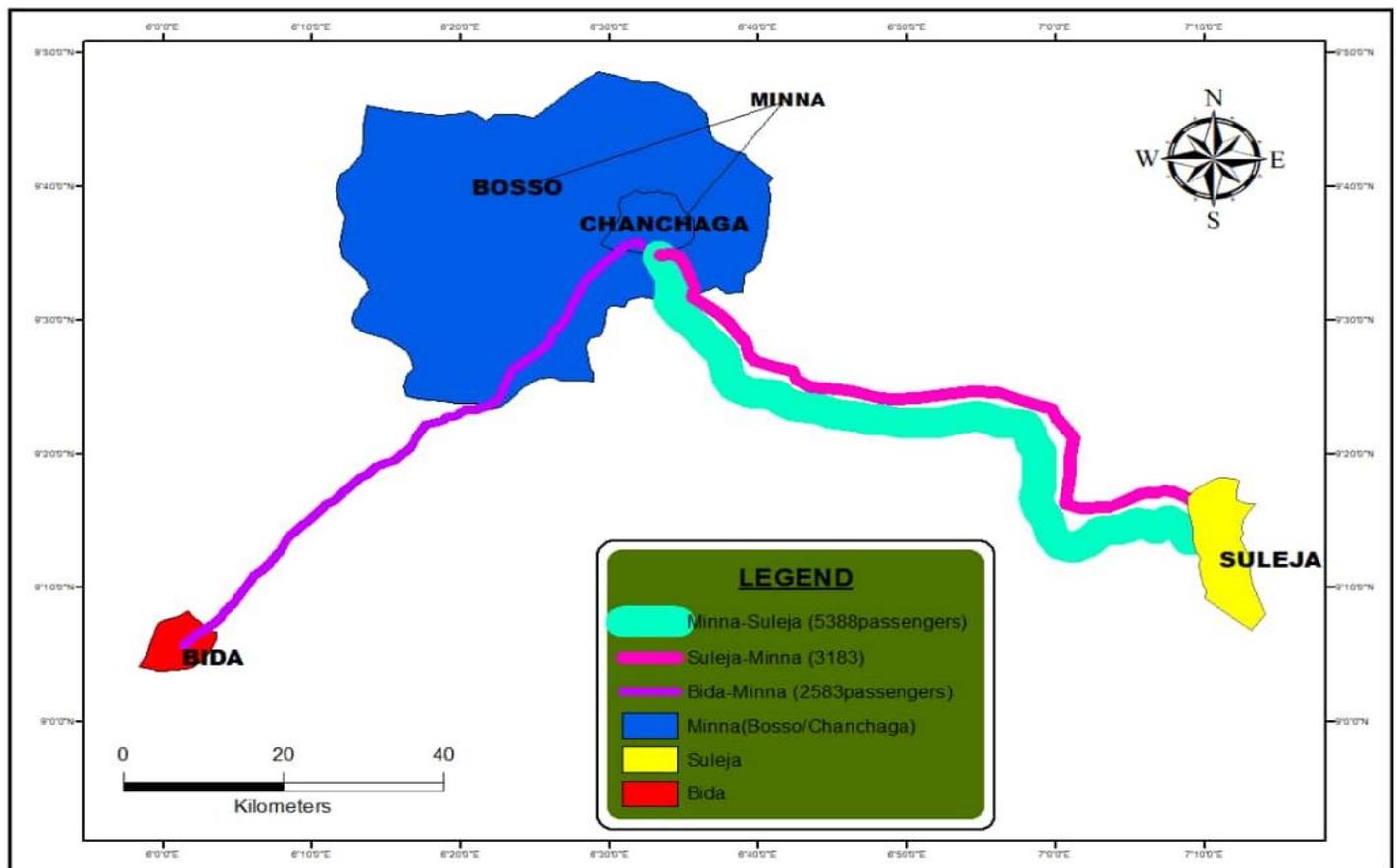


Figure 3. Inter urban trip flow pattern in Niger State.  
Source: Ojekunle et al. (2019)

**Table 2.** Correlation analysis of dependent and independent variables.

Variable	ITF	TD	TT	PP	PI	FC
ITF	1					
TD	.665	1				
TT	.730	.996	1			
PP	.999 <sup>*</sup>	.638	.706	1		
PI	.979	.500	.577	.986	1	
FC	.695	.999 <sup>*</sup>	.999 <sup>*</sup>	.669	.535	1

ITF= Inter Urban Trip Flow, TD =Travel Distance, TT =Travel Time, PP =Population and PI =Public Institution and FC = Fare Charged.

Source; Computer Output from SPSS (2019).

**Table 3.** Regression coefficients<sup>a</sup>.

Model		Unstandardized coefficients		Standardized coefficients	t	Sig.
		B	Std. error	Beta		
1	(Constant)	-488.441	156.182		-3.127	.197
	Population	0.017	0.001	0.999	28.017	.023
2	(Constant)	-793.803	0.000		.	.
	Population	0.016	0.000	0.967	.	.
	Foco	0.717	0.000	0.048	.	.

<sup>a</sup>Dependent Variable Source: Computer Output from SPSS (2019).

**Table 4.** Model summary.

Model	R	R Square	Adjusted R square	Std. error of the estimate
1	0.999 <sup>a</sup>	0.999	0.997	74.510
2	1.000 <sup>b</sup>	1.000	.	.

<sup>a</sup>Predictors: (Constant), population (PP); <sup>b</sup>Predictors: (Constant), population (FC).  
Source: Computer Output from SPSS

2 is that all the independent variables are positively related to dependent variable, which implies that as dependent variable increases the independent variables also increase. Also, all independent variables are positively related to one another, which imply that they all increase or decrease together at the same time.

### Regression output and interpretation

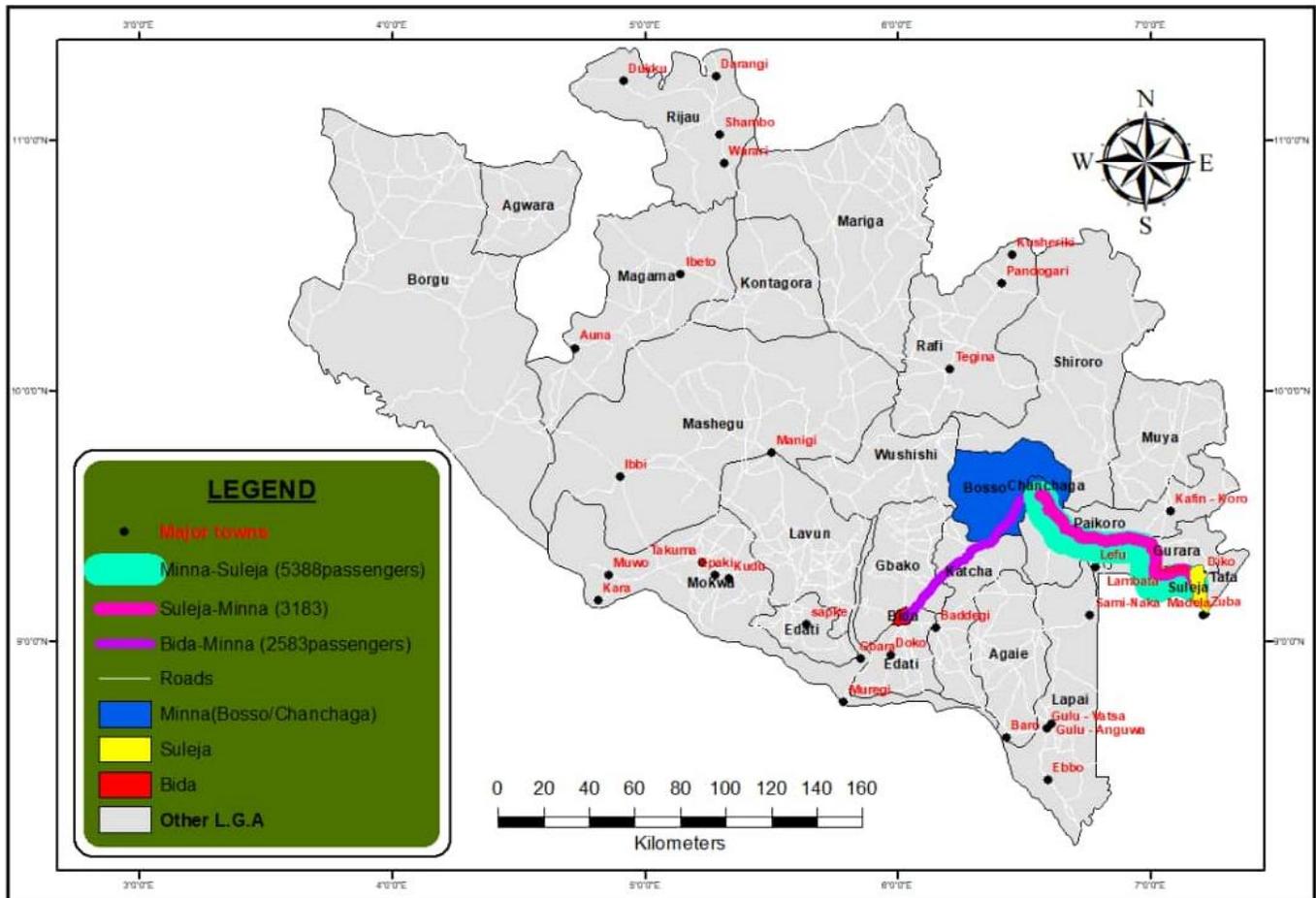
A multiple stepwise regression model was adopted for identifying the key determinant of inter urban trip flow in the study area. The stepwise regression is useful because it helps to eliminate redundant variables especially when it was discovered there was a high level of multi collinearity among the six variables. Table 3 only two variables actually entered the stepwise regression model namely; Population of each town (PP) and the

Fare charged (FC). The table shows the regression coefficient of two independent variables and their level of significance. It shows the regression coefficient for the independent variables and the constant term in the second column labelled "B". The column shows a constant term (a) of-793.803, PP is.016 and FC is.717.

The least squares equation for predicting inter urban travel flow pattern among the towns in Niger State = - 488441+ .016 (Population) + 717 (Fare Charged).

Table 4 shows the model summary, the computation of the coefficient of determination (R-square) shows that the strength of the relationship (R-square) for model 'a' is .999. This implies that population alone accounts for 99.9% of the variation in the flow of inter urban trips between and among the urban centres in the State.

The second model 'b' shows that two variables, that is, population (PP) and fare charged (FC) account for 100% of the inter urban trip generation and attraction among



**Figure 4.** Spatial pattern of inter urban travel flow in Niger State  
Source: Ojekunle et al. (2019)

the three towns in the State. One can therefore conclude that population and cost of transportation are the key determinants for the flow of inter urban trips generated and attracted in Niger State Figure 4.

### Conclusion

The study attempts to find explanations for the pattern of inter urban trip flow in Niger State and develop a model that can be useful in estimating inter urban travels in the State. From the results of analyses, it is discovered that population of each town and cost of travel are the key determinants for estimating trips generation and attraction among major towns in Niger State and Minna and Suleja is the most trip generating and attracting urban centres in the State. The above findings therefore no doubt have implications for regional transportation planning of Niger State. The study covered only three towns due to limited financial resources, it is hoped the future research efforts will be expanded to cover other towns in the State and country.

### Recommendations

Based on the above findings and conclusion, the following recommendations are hereby made;

1. Provision of adequate and efficient public transport system for inter-city travelers should be made by Niger State government through Niger State Transport Authority (NSTA) directly or indirectly with strong alliance with other public transport operators. Furthermore, the Niger State Transport Authority (NSTA) needs to redirect its services to inter-urban routes within Niger State instead of focusing only on inter-state services.
2. A special attention should be given to Minna-Suleja route, since the route has the highest inter-urban travel in the State. The public transport services along the route should be improved upon both in term of quality and quantity to meet the growing demand.
3. It is equally important to keep the fare (that is, cost of travel) as low as possible because it is discovered that travel cost plays a key role in inter-urban travel in the State.

4. Furthermore, it is important that the State Government should embark on more comprehensive regional transportation planning in the state so that future inter urban mobility need of the people can be guaranteed.
5. Finally, a further search is necessary to cover other towns like: Kontagora, Mokwa, Borgu and Kainji in the state in order to further establish the reliability and validity of the model.

## CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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