

**GEOGRAPHIC INFORMATION SYSTEM-BASED TRAFFIC
ANALYSIS ZONING OF FEDERAL
CAPITAL CITY (FCC)**

BY

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DECLARATION

I declare that the work in this Dissertation entitled “Geographical Information System-based Traffic Analysis Zoning of Federal Capital City (FCC) ABUJA was done by me in the Civil Engineering Department, under the supervision of Dr. A. T. Olowosulu. The information derived from literatures has been duly acknowledged in the text and a list of references provided. No part of this thesis was previously presented for another degree or diploma at any university elsewhere.

Sunday Olayinka Atomode

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Signature

Date

DEDICATION

To God Almighty, the Creator of the Universe and it's entirety and to my beloved wife, Folashade Atomode.

CERTIFICATION

This dissertation entitled Geographical Information System-based Traffic Analysis Zoning of Federal Capital City (FCC) ABUJA” by SUNDAY OLAYINKA ATOMODE

Meets the regulations governing the award of the degree of Master of Science of Ahmadu Bello University, Zaria, and is approved for its contribution of knowledge and literary presentation.

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ABSTRACT

World over, there has been an increasing research into the field of Geographic Information System (GIS) with particular emphasis on addressing myriads of day to day issues with the application. One of such area that has received wide attention is Transportation Planning. This therefore underscores the urgency and appropriateness of this research. This dissertation puts forward an efficient method for the Traffic Analysis Zoning (TAZ) of the Federal Capital City (FCC) which is necessary for implementing a planning process with Geographic Information System (GIS) for Transportation (GIS-T), using statistical spatial data analyses and GIS technology. The major roles of GIS in this method includes the production of basic spatial units (BSUs) with topological data structure, the integration of various procedures during the TAZ generation including computer program routines and the visualization of the output of each TAZ generation. One of the most significant reasons for obtaining well-defined TAZs is the fact that they are defined at the outset of transportation demand modeling, used from trip generation to trip assignment, and will ultimately affect transportation policy decisions.

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CHAPTER ONE

INTRODUCTION

1.1 PREAMBLE

The applications of a GIS are vast and continue to grow. By using Geographic Information System (GIS) scientist can research changes in the environment, engineers can design road systems, electrical companies can manage their complex network of power lines; governments can track the uses of land, and police departments can plan emergency routes. Many private businesses have begun to use a GIS to plan and improve their services.

The Canadian government built the first GIS, the Canada Geographic information system during the 1960s to analyze data collected by the Canada land inventory (Miller and Shawn 2001). Other government and university laboratories soon built simulator similar systems. However, GIS systems were not widely used until the late 1970s, when technological improvements and lower costs made computer widely available. GIS sales boomed during the 1980s, as government and businesses found more users for the systems. A number of companies began producing new GIS software to program computer systems to increase their functions. As at the early 1990s, about 100,000 GIS systems were already in Operation (Shawn 2002).

Over the years, there have been much progress in all facets of GIS in transportation planning known as GIS-T and a wide variety of applications have emerged. A number of notable GIS and related advances have paved the way to the application in urban transportation. These include; data capture methods, spatial integration technologies, technology platform, GIS as a platform for modeling transportation system, web technologies, and organizational facilitators. Brief descriptions are provided in this research work. Owing to favourable future conditions, it is expected that GIS will play an increasingly important role in transport planning and management (Peak 2000).

1.2 GEOGRAPHIC INFORMATION SYSTEMS FOR TRANSPORTATION (GIS-T)

In a broad sense a geographic information system (GIS) is an information system specializing in the input, management, analysis and reporting of geographical (spatially related) information. Among the wide range of potential applications, GIS can be used for, transportation issues have received a lot of attention. (A specific branch of [GIS applied to transportation issues](#), commonly labeled as GIS-T, has emerged). Geographic Information Systems for Transportation (GIS-T) refers to the principles and applications of applying geographic information technologies to transportation problems [Miller and Shaw, 2001]. GIS-T research can be approached from two different, but complementary, directions. While some GIS-T research focuses on issues of how GIS can be further developed and enhanced in order to meet the needs of transportation applications, other GIS-T research investigates the questions of how GIS can be used to facilitate and improve transportation studies [Shaw, 2002].

Transportation planning is the process of examining travel and transportation issues and needs in traffic areas. It includes a demographic analysis of the community in question, as well as an examination of travel patterns and trends. The planning process includes an analysis of alternatives to meet projected future demands, and for providing a safe and efficient transportation system that meets mobility while not creating adverse impacts to the environment. In Municipal areas with over 50,000 populations, the responsibility for transportation planning lies with designated Municipal Planning Organizations (MPO).

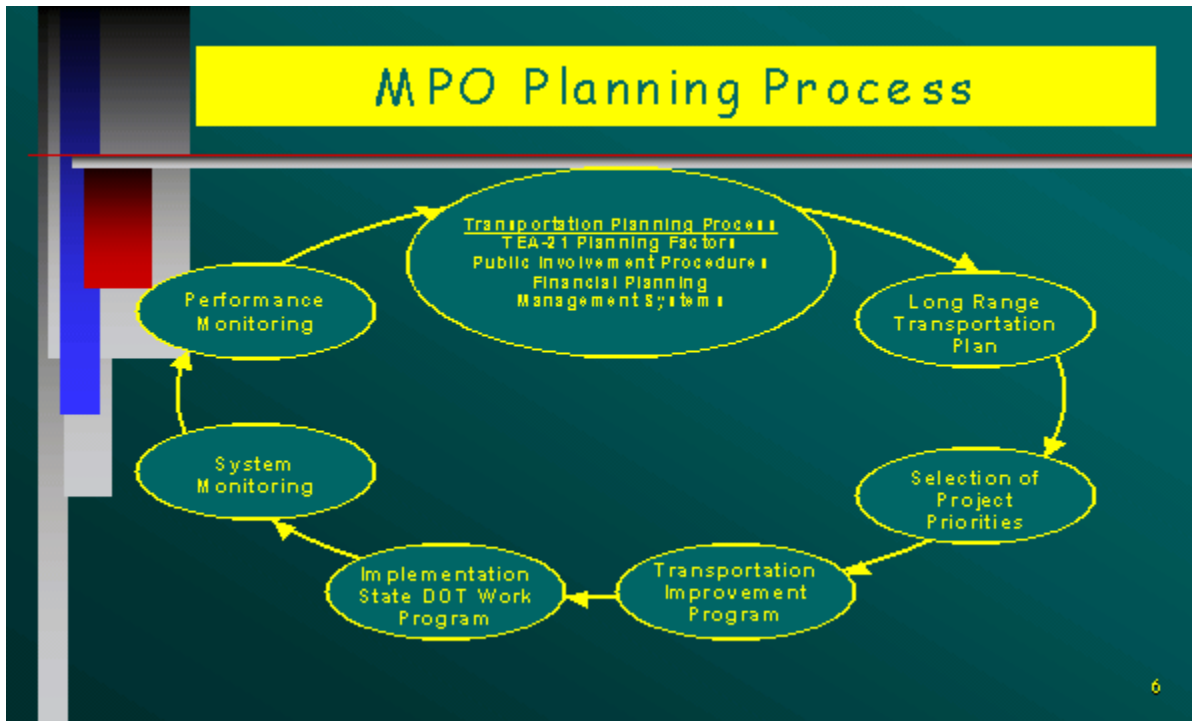


Fig 1.1: Typical transportation planning process for a municipal area.

For effective planning and for digital analysis, the process of delineation must be considered.

1.3 AIM

The aim of this research is to create a framework for the Traffic Analysis Zoning (TAZ) of Federal Capital City (FCC) using Geographical information System (GIS).

1.4 STATEMENT OF RESEARCH PROBLEM

Although the benefits of GIS are vast and continues to increase, there has to be a specific framework for harnessing such benefits. In developed countries, GIS is widely used address transportation issues. Such advancement however came as a result of the organized computer-based framework for the analysis and processing of transportation related data. There is therefore the need to create a GIS

framework for transportation issues in developing nations such as Nigeria so that the immense benefits of GIS becomes readily accessible to all and most especially planners at all levels.

1.5 OBJECTIVE

To achieve this aim, the following are the objectives:

1. Digitizing the map of the Study area.
2. Creating a database for the planning.
3. Generating data analysis using Arc 9.3.
4. Creation of Traffic Analysis Zone (TAZ) map.
5. Creation of Origin and Destination Survey Matrix(O-D Matrix)
6. Creation of Desired Line

1.6 JUSTIFICATION

The study is meant to highlight GIS as a planning tool for transport planners, the benefit of which is hoped to harness the following.

- Data collection cost reduction, data maintenance cost reduction, improved data reliability and most important application not otherwise possible.
- Integration of data which generally makes it possible to study many relationships among two or more data element.
- Growth in integration system which will affect the cost of providing linkage rapidly by the value of the increase in information that the system provides.

- Forecasting of future plans in traffic zone analysis as it affects transportation impact analysis and public transit operation.

1.7 SCOPE OF WORK

The research work will cover the following areas:

- Overview of GIS – T.
- Analysis of Traffic Analysis Zoning.
- Delineation of Traffic Analysis Zones.
- Generation of O-D Matrix.
- Creation of desire line using GIS.

CHAPTER TWO

LITERATURE REVIEW

2.1 INTRODUCTION AND RESEARCH BACKGROUND

There is a powerful synergy between GIS transportation modeling system. In the context of this research, Geographic Information System (GIS) is defined as “a system of computer hardware, software and procedures designed to support the compiling, storing, retrieving, analyzing and display of spatially referenced data for addressing planning and management problems. In addition to this technical component, a complete GIS must also include a focus on people, Organization and standards” (Biln et al 1993). A similar definition is provided by the U.S Federal Highway Administration (2004) and Syed Anees Ahmed (2003).

GIS present a powerful new means of efficiently managing and integrating the numerous types of information necessary for the planning, design construction, analysis, operation, maintenance and administration of transportation systems and facilities.

Canada is a world leader in early innovation in GIS. The Canadian GIS, the first known mainframe based operational system was developed for environment Canada in the 1960s (Lukes 1991) Oxford Country Ontario has attracted international attention for its multi-purpose GIS implementation which required the coordination and integration of data from various municipalities and provincial government data bases (Khan 1995). Increasing number of Canadian urban area is benefiting from GIS

initiatives. Also, GIS is enabling the application of smart (sustainable) development concepts and intelligent transportation system.

This research describes advance in geographic information system and discusses applications of GIS in the planning and management of urban transportation systems. Additionally, it discusses requirement, applications and benefits of GIS in urban transportation planning.

Nowadays, urban transportation systems analysis and modeling require 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, information technologies and visualization tools are becoming prominent.

Generic in nature but specific to the methodological procedures undertaken in the Greater Montreal Area (GMA), the CATI (Computer-Assisted Telephone Interview) household survey is conducted about every five years over a 5% sample. Typically, it represents about 160,000 people belonging to 65,000 households declaring some 400,000 individual trip records for an average weekday.

Individual trips are geo-referenced for the residence, trip origin and destination, modal junction points (kiss-and-ride and park-and-ride locations), and are described for their household and personal characteristics (age, gender, car license, car ownership, income) in addition to the trip attributes (purpose, mode, departure time, train-subway-bus routes taken if traveling by transit, bridges and highway taken if traveling by car). The validation of the interviews' answers and the completion of the trip details are executed by a GIS-based program (address matching, geo-coded trip generators, access calculations, transit network in service, shortest path computations).

2.2 TRAFFIC ANALYSIS ZONE

A traffic analysis zone is the unit of [geography](#) most commonly used in conventional [transportation planning](#) models. The size of a zone varies, but for typical metropolitan planning software, a zone of under 3000 people is common. The spatial extent of zones typically varies in models, ranging from very large areas in the [exurb](#) to as small as city blocks or buildings in [central business districts](#). There is no technical reason why zones cannot be as small as single buildings, however additional zones add to the computational burden. (Open Shaw, 1997)

Zones are constructed by census block information. Typically these blocks are used in transportation models by providing socio-economic data. States differ in the socio-economic data that they attribute to the zones. Most often the critical information is the number of automobiles per household, household income, and employment within these zones. This information helps to further the understanding of trips that are produced and attracted within the zone. Again these zones can change or be altered as mentioned in the first paragraph. This is done typically to eliminate unneeded area to limit the "computational burden."

A traffic analysis zone (TAZ) is a special area delineated by state and/or local transportation officials for tabulating traffic-related data—especially journey-to-work and place-of-work statistics. A TAZ usually consists of one or more census blocks, block groups, or census tracts. For the 1990 census, TAZs were defined as part of the Census Transportation Planning Package (CTPP). The U.S. Census Bureau first provided data for TAZs in conjunction with the 1980 census, when it identified them as "traffic zones."

Each TAZ is identified by a six-character alphanumeric code that is unique within county or statistically equivalent entity. For the 1990 census, TAZ codes were unique within CTPP area, which generally conformed to a metropolitan area.

2.2.1 Work Zone and Traffic Analysis

To meet safety and mobility needs during highway maintenance and construction, and to meet the expectations of the traveling public, transportation practitioners need to minimize and manage the work zone impacts of road projects. Understanding the anticipated type, severity, and extent of work zone impacts associated with various project alternatives enables practitioners to include appropriate mitigation strategies during project programming, design, and in the development of effective [transportation management plans](#) (TMPs).

Analysis of the work zone may include consideration of items such as the following:

- Mobility and safety impacts of the project at the project, corridor, and network levels.
- The combined impacts of concurrent projects that are located near each other or on the alternate route for another project.
- Impacts on nearby intersections and interchanges, railroad crossings, and public transit and other junctions in the network.
- Impacts on evacuation routes and affected public property.
- Impacts on affected businesses and residences.

Analysis may necessitate the use of analytical tools, depending on the degree of analysis required. Some tools, such as QuickZone and CA4PRS, were designed for work zone related analysis. Other traffic analysis tools that were not designed specifically for work zones may also be useful for analyzing work zone situations (Chapleau 2003).

2.2.2 Quickzone

QuickZone is an easy-to-use computer-based traffic analysis tool that compares the traffic impacts for work zone mitigation strategies and estimates the costs, traffic delays, and potential backups associated with these impacts. The target users of QuickZone are State and local traffic

construction, operations, and planning staff, and construction contractors (Chapleau 2003). QuickZone can be used to:

- Quantify corridor delay resulting from capacity decreases in work zones.
- Identify delay impacts of alternative project phasing plans.
- Support tradeoff analyses between construction costs and delay costs.
- Examine the impacts of construction staging by location, time of day (peak versus off-peak), and season (summer versus winter).
- Assess travel demand measures and other delay mitigation strategies.
- Help establish work completion incentives .

2.2.3 Desire Line

Desire line is synonymous to desired path as presented by Wikitionary and Wikipedia. It represents the shortest or most easily navigated route between an origin and destination. It shows the desire for movement from one place to another. It could be a pedestrian track as in foot path, bicycle lane, set route for vehicles and motorcycles. It connects the origin with the destination. It could also cut across a patch of grass or paths in the snow or over a rugged terrain. The path usually represents the shortest or most easily navigated route between an origin and destination. Even if one is not familiar with the term, desire lines are seen in action every in both rural and urban centres. It is indicative of the demand for transportation between various origins and destinations vis-à-vis the prevalent or available mode of transportation obtainable. For many cities, the grid of streets and transit systems were likely laid down long before the buildings grew up around them, thanks to the rigour of planners and engineers who knew best. But as cities transition in ways that challenge the century old plan, they need new and quick ways to improvise connections between areas of growth. These were later known as “Desire Lines”. It is a term for a trail worn down by foot traffic to create a shorter distance between two points. It also represents user innovation as a faster route between origin and destination. Sometimes, planners

take heed of the suggested changes and reconfigure the paved sidewalks, formalizing the recommended changes. Below, as depicted in figure 2.1, is a typical area view of desire line through a vacant lot in Detroit.



Fig 2.1: Desire paths through vacant lots in Detroit, by Sweet Juniper

Desire lines, like desire paths, are applied on a slightly larger scale, to urban transit movements. A desire line would therefore be a new bus route or bike path or ferry line between two areas people want to go. A subway is about building a larger infrastructural network, in this light, a desire line exists to connect place to place. The beauty of desire lines are not only their light touch, but also the unique multimodal options they can introduce to a city: gondolas stringing up hillsides, ferries chugging between two waterfront neighborhoods. Imagine cities shifting away from the bulky pre-determined routes for cars in favor of diagonal bike paths and pedestrian cut-throughs.

With today's data collection and ability to study traffic patterns, it's much easier for cities to figure out where their residents want to go. Instead of massive capital campaigns, expect to see a lot more nimble

"desire line" transit knitting together our cities. In Urban Planning, the concept of desire paths can be used when analyzing traffic patterns in any mode of travel (Alissa Walker 2014).

2.2.4 Geographic area Description

A traffic analysis zone (TAZ) is a special area delineated by state and/or local transportation officials for tabulating traffic-related data- especially journey-to-work and place-of-work statistics. A TAZ usually consists of one or more census blocks, block groups, or census tracts. For the 1990 census, TAZs were defined as part of the Census Transportation Planning Package (CTPP). The U.S. Census Bureau first provided data for TAZs in conjunction with the 1980 census, when it identified them as "traffic zones." Each TAZ is identified by a six-character alphanumeric code that is unique within county or statistically equivalent entity. For the 1990 census, TAZ codes were unique within CTPP area, which generally conformed to a metropolitan area (Binetti 1996).

2.2.5 A Recommended Approach to Delineating Traffic Analysis Zones

Procedure based on detailed guidance on the best practices in delineating traffic analysis zones (TAZ), either for a new travel demand model, or to further refine an existing travel demand model is here highlighted. One can define a TAZ, also referred to as a zone, as the following:

TAZs serve as the primary unit of analysis in a travel demand forecasting model. They contain socioeconomic data related to land use. TAZs are where trips begin and end (Barton – Aschman Associates 1998). One may refine TAZs to improve the accuracy of a model, such as to reflect a new or revised development of regional impact (DRI), conduct a subarea analysis, reflect new roads or political boundaries, for the purpose of validating a model, and/or to assist in delineating socioeconomic data based on Census boundaries and other geographies. One should consider

roadway network and physical geography when delineating TAZ boundaries. However, there are other considerations that are sometimes overlooked. One should also consider the following additional factors when delineating TAZs:

Highway network compatibility:

- Existing and planned transportation facilities; and
- Centroid connector loadings.

Boundary compatibility:

- Physical geography;
- Census geography;
- Political geography;
- Planning District/Sector boundaries; and
- Irregular zone geography.

Socioeconomic data (existing and future):

- Homogeneous land uses, where feasible;
- Special generators;
- Trips per zone; and
- Developments of regional impact.

Access:

- Transit access; and
- Freight/intermodal facilities.

Other considerations:

- Zone size and intrazonal trips; and
- Internal versus external zones.

2.3 ZONE SIZE AND QUANTITY

The ideal size of a TAZ depends on what the model will be used for. Below are ideal zone sizes for three typical uses (Barton 1998):

1. **Large-Sized Zones for System or Statewide Planning** – TAZs can be larger than the arterial grid and with up to approximately 20,000 persons per zone;
2. **Medium-Sized Zones for Arterial Planning** – Two or more arterials should not traverse the TAZ in any direction and with up to approximately 4,000 persons per zone; and
3. **Small-Sized Zones for Corridor Analysis** – TAZs in a corridor or subarea should be more refined and should be greater than 1,200, but less than 3,000 persons per zone.

If the model network is sparse, the TAZ structure usually includes larger zones to accommodate the sparse highway network. If a model network is more detailed, smaller TAZs are required to accommodate the additional network detail (Binetti, 1996).

Although TAZs can be as small as a single block, they are usually between 0.25 to one square mile in area (Beigborn 1995). One should consider the intended use of the model and what data is used to populate the TAZs when determining the appropriate size of the TAZs. One can calculate

the area of a TAZ in GIS using the TAZ boundary shapefile, and then querying all TAZs with an area greater than one square mile. Those larger TAZs can then be reevaluated to determine if further disaggregation is feasible. Most models usually have between 500 and 2,000 TAZs (Ibid), depending upon the size and density of the planning area. The smaller the TAZs, the more accurate the forecasts might be. However, having a higher number of TAZs in the model does require more detailed data. It is recommended that the model developer consider any TAZ splits made during corridor studies for inclusion during the next model update.

According to the U.S. Census, Census tracts should include between 1,200 and 8,000 persons, with an optimum size of 4,000 persons. Trip production rates vary among household type, auto availability, and other household characteristics. Trip attraction rates vary among employment type and region. However, using a national average trip production rate of 3.64 to 3.87 trips per person (Barton 1997), assuming 4,000 people per Census tract, approximately 15,000 trips per day are produced from the one Census tract, assuming the zone did not include any employment to attract trips. One should consider splitting zones exceeding 15,000 daily trips to achieve smaller-sized zones, such as those used for corridor planning. If the Census tract were denser with upwards of 8,000 persons, one would need to disaggregate the Census tract further for the purposes of defining the TAZ structure, based on person trips generated per zone alone. The Census Bureau is currently considering increasing the minimum number of persons per block group (and potentially TAZs) to 1,200 persons (previously 600) or 480 households. The existing maximum thresholds of 3,000 persons and 1,200 households per block group remain unchanged. As a result, the number of persons per TAZ should be greater than 1,200, but less than 3,000 for base year TAZs.

If the geographic size of a TAZ is too large and a TAZ has both productions and attractions (dwelling units and employment), one may reduce the trips assigned to the roadway network due to a larger number of intrazonal trips. Intrazonal trips are those that are short enough to begin and end within the same zone and, thus are not assigned to the roadway network. TAZs that include only

employment or only dwelling units may also have intrazonal trips, but only for the nonhome-based trip purpose (FHA 1990). One may reduce the number of intrazonal trips by decreasing the size of the TAZ. In addition, reducing zone size should decrease intrazonal travel times, potentially enhancing performance of the gravity model trip distribution process. Additionally, if the TAZ is too large, an over-representation of trips on centroid connectors can erroneously load an excessive number of trips on a highway network link. As a general rule of thumb, centroid connector loadings should be less than 10,000 to 15,000 vehicles per day (FHA 1990). Lastly, if two or more transit stations or highway interchanges are located on the same TAZ boundary, one may likely need to split the zone to achieve a proper loading of trips.

2.3.1 Internal Versus External Zones

TAZs inside the study area, or model boundaries, are defined as internal zones. Those zones outside the study area along the model boundaries are defined as external zones or external stations. To accurately reflect travel patterns within the study area, the study area should be large enough so that nearly all (over 90 percent) of the trips begin and end within the study area (Being born 1995).

2.4 BOUNDARY COMPATIBILITY

2.4.1 Physical Geography

Physical geography refers to any permanent visible feature that might restrict access and act as a barrier for free movement. Some of these features may include:

Water bodies, such as bays, lakes, rivers, canals, and Natural barriers, such as wetlands and steep slopes.

The primary reason for using physical geography to delineate TAZ boundaries is to provide

realistic access from the TAZ centroid to the nodes on the model network. Centroids are coded into the model network to identify the center of activity within a zone. Centroid Connectors are coded into the model network to connect the centroids to transportation facilities, usually representing access via local roads or major driveways. Having a centroid connector passing through a physical barrier conflicts with the assumption of free movement from the TAZ onto the network, as the barrier does not allow for such movement.

Understanding the physical geography provides the modeler with an ability to determine accessibility between TAZs and transportation facilities. Useful information on this. Figures 2.17a, 2.17b, and 2.17c provided.

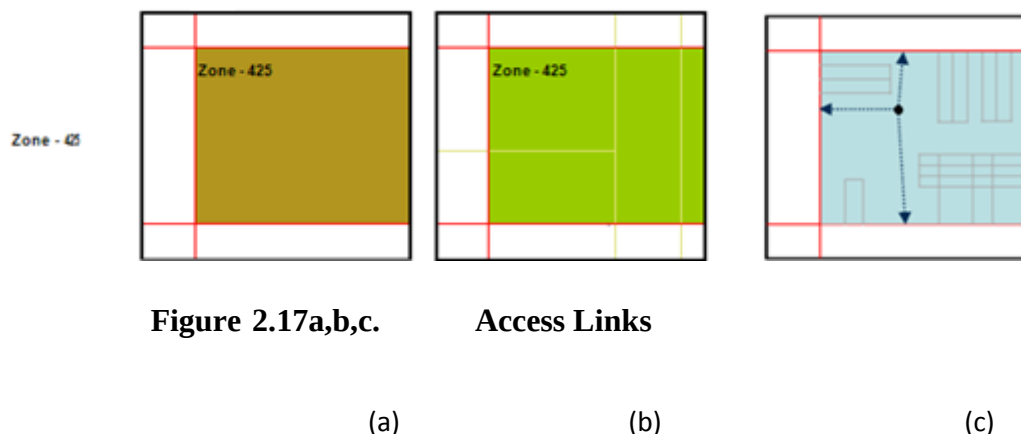


Figure 2.17a indicates access links traversing water body.

Figure 2.17b indicates access links over collectors shown in yellow.

Figure 2.17c indicates access links connect to model network ignoring the lack of underlying connectivity of all local roads (in gray).

As shown in Figure 2.17a, not considering the existence of a water body may result in the centroid connector traversing the water body. Figure 2.17b indicates centroid connectors crossing collector roads. In reality one would use collector streets to connect with major roads.

Figure 2.17c indicates the need for understanding the connectivity of underlying local roads, even if they are not included in the model network. This understanding helps in providing realistic linkage to the model network. In Figure 2.17c, the underlying local road structure indicates that local street access exists to all four bordering arterial streets, but no centroid connector is included to the right (east).

How to Use Physical Geography

One can collect data on physical features that may potentially restrict movement from several publicly available sources. As mentioned earlier, a few important features include water bodies and any topological and environmental barriers. In terms of water bodies, all kinds of water bodies, such as marshy lands, lakes, or rivers, provide physical barriers, and hence, one must consider them in determining TAZ boundaries. One should also consider other barriers, such as steep slopes, presence of natural habitats, and conservation areas.

Upon obtaining the data layers for these physical features, a simple rule of thumb is to delineate TAZs bounded by these permanent physical features. As depicted in the figures below, delineating TAZs bounded by these permanent barriers would assist in providing realistic linkages between the TAZ centroids and the network. Referring to earlier examples, Figure 2.18a represents a better way.

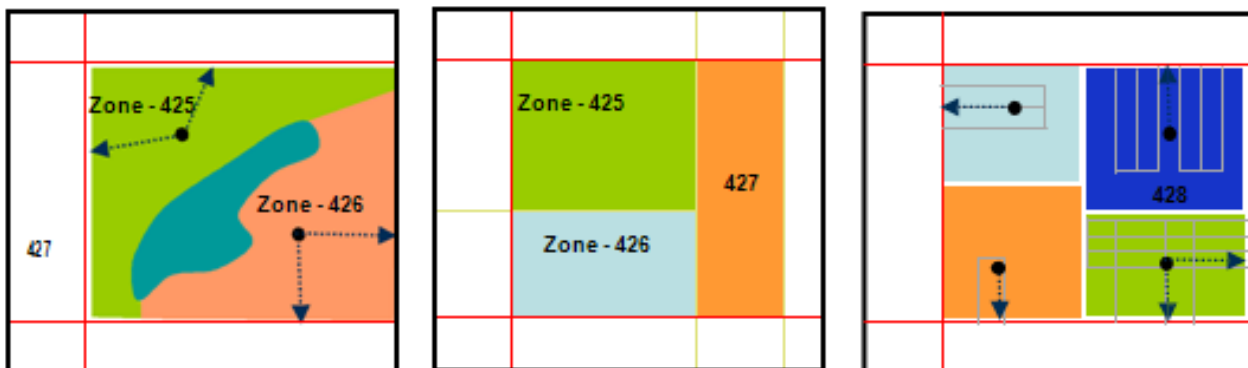


Figure 2.18a indicates zones being delineated using boundaries of water body.

Figure 2.18b indicates zones being delineated using major roads as boundaries.

(a)

(b)

(c)

Figure 2.18c indicates zones being delineated using connectivity depicted by local roads.

Similarly, Figure 2.18b shows how TAZs can be delineated based on the location of major roads, while Figure 2.18c shows the usefulness of having data on minor roads in terms of delineating TAZ boundaries.

2.4.2 Census Geography

Census boundaries cover a wide range of geographic detail, ranging from Census blocks to block groups and Census tracts. Figure 2.19 below provides an example of blocks (light grey streets), the smallest geographic unit of the Census; block groups (shaded colors); and Census tracts (red boundaries).

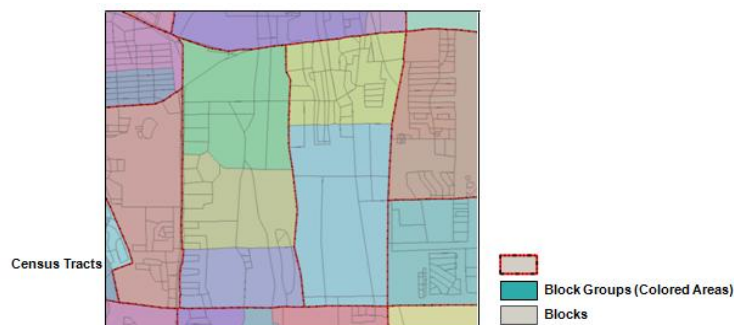


Figure 2.19 Blocks versus Block Groups versus Census Tracts

Why Use Census Geography?

Travel demand models typically use a variety of demographic data as inputs. These data are developed at a TAZ level and input into the models. Population and dwelling units are two widely used attributes that are also available at a variety of Census geographies. The Census collects and reports these data every 10 years by Census geography.

Formulating TAZ boundaries along the Census geography enables modelers to readily access all Census demographic data or any other datasets like the Census Transportation Planning Package (CTPP) that are based on census geography. CTPP is a comprehensive set of special tabulations from the decennial census designed for transportation planners to enable them to analyze demographic and travel trends (US Dept of Transportation) that facilitate validation of model inputs. CTPP typically provides data at various census geographic levels (from state to block group); hence, formulating TAZ boundaries along census geography provides seamless access to all information from CTPP. Further, with the growing importance of the American Community Survey (ACS) in regard to travel demand model calibration and validation, another census geography known as Public Use Microdata Areas (PUMAs) can be beneficial. A PUMA is an area with a decennial census population of 100,000 or more people for which the Census provides specially selected extracts of raw data from a sample of long-form census records. The delineation of PUMAs are based on Census 2000 population counts and are based on several rules and guidelines prescribed by the Census Bureau (<http://www.trbcensus.com/articles/pumaguidelines.pdf>). According to these guidelines, PUMA boundaries should be for the most part, contiguous (except when counties are discontinuous), and can

only follow the boundaries of geographic areas such as counties or statistical equivalent areas, minor civil districts (MCDs), Census tracts (but only within counties that have more than 100,000 people) and places (with exceptions for unincorporated places). The information that the Census provides is referred to as a “public use microdata sample (PUMS)” file. Typically, two types of PUMAs are delineated as follows:

Areas that contain at least 100,000 people. The PUMS files for these PUMAs contain a five percent sample of the long-form records. Figure 2.20 illustrates the PUMAs that contain a five percent sample.

Areas that contain at least 400,000 people, also known as super-PUMAs. The PUMS files for these super-PUMAs contain a one percent sample of the long-form records. The larger one percent PUMAs are aggregations of the smaller five percent PUMAs.

PUMAs of both types, wherever the population size criteria permit, comprise areas that are entirely within or outside metropolitan areas or the central cities of metropolitan areas.

ACS, which is a key part of the Census Bureau’s Decennial Census Program, provides annually updated data on the characteristics of housing and population. The bureau releases this data for legal, administrative, or statistical areas with estimated populations of 65,000 or more. (US Census Bureau). Although ACS estimates are available for several census geographies, PUMAs are the smallest geographic areas (that include both rural and urban areas) at which ACS data is published. Nesting TAZ boundaries within PUMAs enables modelers to take advantage of ACS microdata that assists in evaluating relationships among variables not shown in the standard products offered by the Census Bureau.

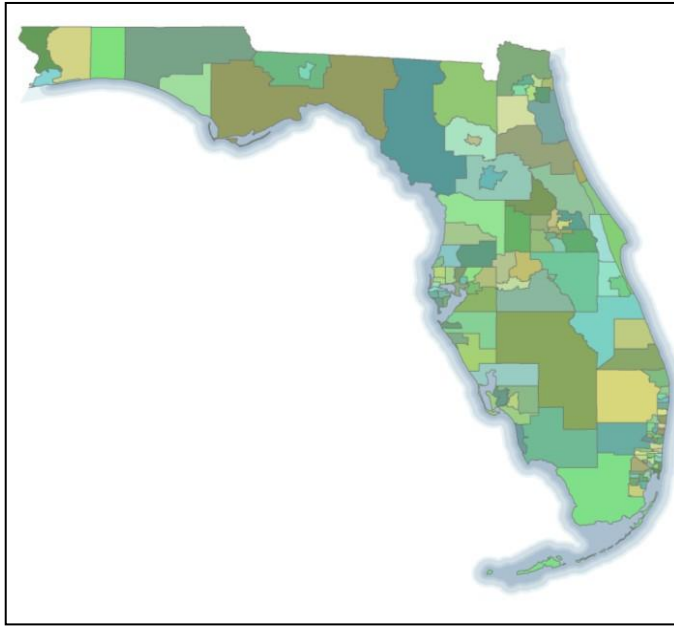


Figure 2.20: PUMAs in Florida that Contain a Five Percent Sample (at least 100,000 people)

However, note that since Census geography is oriented around population and dwelling units, employment-oriented areas, such as Central Business Districts (CBDs), warehouse districts, and office parks tend to have very large tracts. As a result, employment-oriented areas likely need further subdividing.

In addition to covering a wide range of geography, Census geography offers an advantage of being hierarchically nested. This nesting enables users to easily aggregate and disaggregate Census data over a variety of geographies. For example, data from a lower geographic unit, such as block groups, can be aggregated to relate to data from tracts, and disaggregated to relate to data from blocks. Having a TAZ structure consistent with Census geography also enables such disaggregation or aggregation to be conducted at a TAZ level, using data from Census geographies. This can be extremely useful when refining TAZ boundaries in terms of being able to use data from the Census geographies to derive data for refined TAZ boundaries.

How to Use Census Geography

Of all the Census geographies, the Census Bureau defines Census blocks as the smallest geographic entity for which the Bureau collects and tabulates 100 percent decennial Census data. Census blocks are defined as “areas bounded on all sides by visible features, such as streets, roads, streams, and rail- road tracks; and by invisible boundaries, such as city, town, township, and county limits; property lines; and short, imaginary extensions of streets and roads.” (US Census Bureau 2000). These blocks can be used as “building blocks” for delineating TAZ boundaries. Once the analyst determines the area and extent of the TAZ using various criteria that are described in later sections, TAZ boundaries can be delineated using one or more of these building blocks. The size of a typical block varies from a well developed area to a sparsely settled area.

In Figure 2.21, the grey lines indicate the block boundaries, and the yellow ones indicate the TAZs. As seen in the figure, one can use blocks theoretically as building blocks to delineate TAZs, although reporting of select Census attributes is more limited at the block level.

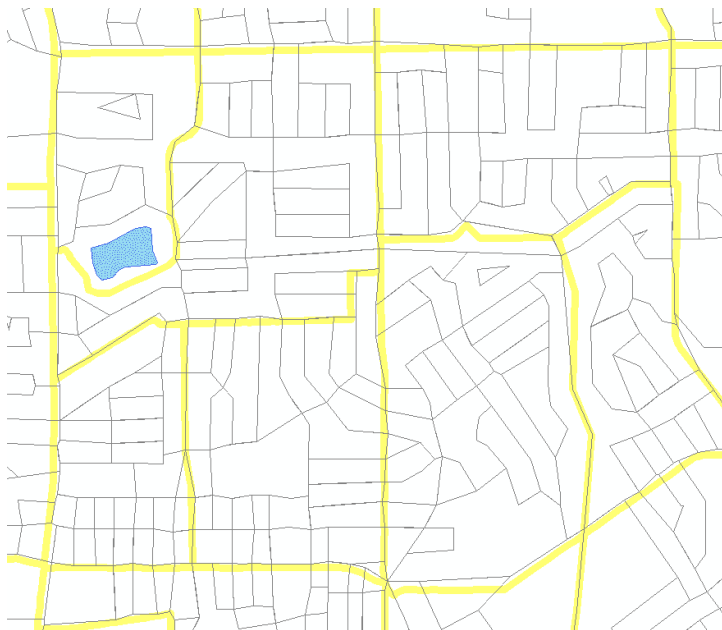


Figure 2.21

Delineating TAZs Based on Block Boundary

If the extent of the TAZ spans over a number of blocks, then one might consider using larger units of geography, the Census block group boundaries, to delineate TAZs. Census block groups are defined as “a cluster of Census blocks having the same first digit of their four-digit identifying numbers within a Census tract. For example, for Census 2000, BG 3 within a Census tract includes all blocks numbered between 3,000 and 3,999. The block group is the lowest-level geographic entity for which the Census Bureau tabulates sample data from the decennial Census.” (US Census Bureau 2000). So, if the extent of TAZs is fairly larger when compared to block sizes in an area, one can then check block groups to see if those can be used as references for delineating TAZ boundaries. As shown in Figure 2.22 where the colored areas indicate various block groups, if the required size of a TAZ matches that of a block group, then one can delineate that TAZ over the block

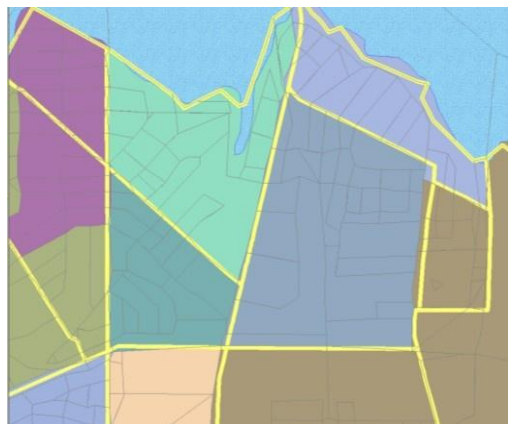


Figure 2.22: indicates how a TAZ boundary can be delineated based on a block group boundary. Colored areas indicate block groups.

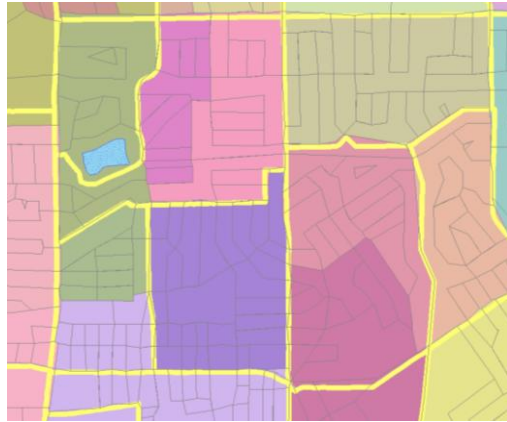


Figure 2.23: shows how to delineate TAZ boundaries for areas traversing partially over multiple block groups. Colored areas indicate block groups.

One can apply similar logic for TAZ areas that need to span across several block groups. In such cases, one can use the next larger unit of Census geography, the Census tract boundaries. Census tracts are defined as “a small, relatively permanent statistical subdivision of a county or statistically equivalent entity, delineated for data presentation purposes by a local group of Census data users or the geographic staff of a regional Census center in accordance with Census Bureau guidelines.

For purposes of travel demand modeling, one should use tracts as the largest size of building blocks for delineating TAZ boundaries. According to the U.S. Census Bureau, these tracts are designed to be relatively homogeneous units with respect to population characteristics, economic status, and living conditions at the time they are established. This translates into homogeneity in terms of travel patterns inside each Census tract. Therefore, ensuring that the boundaries of the largest TAZs correspond to Census tract boundaries may assist with depicting travel patterns more accurately.

Further, Census tract boundaries are delineated with the intention of being stable over many decades, so they generally follow relatively permanent visible features, which meets one of the important criteria for delineating TAZs.

Note that local agencies are provided the opportunity to review and suggest modifications for the delineation of block groups, census tracts, census county divisions, and census-designated places for the purpose of reporting data from the 2010 Census through the Participant Statistical Areas Program (PSAP). Modeling staff should participate in this process to learn what the new census tract and block group boundaries are.

2.4.3 Political Geography

Political geography refers to all politically delineated boundaries, such as cities, counties, MPOs, and states. Political geography also incorporates any other local or regional jurisdictional boundaries reflecting public entities.

Why Use Political Geography?

The primary purpose of delineating TAZ boundaries consistent with political geography is for subarea analysis of model outputs. Entities using travel demand models often need to analyze/evaluate travel patterns relevant to certain predefined political geographies, such as cities or counties. Nesting TAZs within this political geography facilitates easy grouping of TAZs that fall within that geography, and assists in aggregating outputs from the travel demand models. Having a TAZ structure consistent with political boundaries also assists in isolating and extracting certain sets of TAZs according to their location under political boundaries, and analyzing travel patterns relevant to each jurisdiction or within different political geographies. For example, if an MPO wishes to

identify the magnitude of travel between each of its cities, having the TAZ boundaries consistent with city boundaries assists in the aggregation of data for each city, and then enables the modeler to conduct an intracity travel pattern analysis.

How to Use Political Geography

The first step in delineating TAZs based on political geography is to identify all political geography that is of interest for analysis. Upon deciding that, one should collect data depicting the relevant political geography either from a public source, if available, or through a process of digitization or georeferencing in software such as ArcGIS.

As in the case of physical geography, upon obtaining the political boundary data, make sure that no TAZ boundary partially overlaps with a political boundary

Upon successful delineation of TAZs based on political geography, it might be helpful to assign all TAZs that fall within a certain political geography a logical series of numbers. For example, one can assign numbers ranging from 1 to 99 to all TAZs that fall within a given political boundary, such as a city. One can assign numbers ranging from 100 to 199, and so on, to all TAZs that fall within a different city. Following this procedure would greatly assist in easily querying and extracting all TAZs that belong to a particular city. Even if the city does not have 100 TAZs inside its boundary, for example, it has only 50 TAZs inside it, it would still be helpful to reserve TAZ numbers from 51 to 99 available for any the cities.

2.4.4 Planning Districts and Sectors

Ideally, TAZs should be nested completely within planning district or sector boundaries. As noted above, this allows for easier reporting of data, such as demographics; productions and attractions; or

trips, by planning district or sector. One can use zone-to-district equivalency tables to compress matrices, such as trip tables, to summarize statistics or trips by district. In addition, one should nest TAZs within CBD boundaries, if at all possible.

2.4.5 Irregular Zone Geography

Irregular zone geography can cause the “lumping” of trips onto the roadway network unrealistically. For example, as illustrated in Figure 2.22, if a TAZ is mostly rectangular in shape, the longer centroid connectors will not assign as many trips due to link distance. As a result, the trips most likely load from the centroid to the roadway network using the shorter centroid connectors;

2.5 SOCIOECONOMIC DATA

2.5.1 Homogeneous Land Uses

Land use refers to the manner in which portions of land or the structures on them are used, such as commercial, residential, retail, industrial, etc. (Planning glossary, US DoR). Homogeneous land uses are those that are similar in nature, such as TAZs that include mostly households or mostly employees.

Why Use Homogeneous Land Uses?

In areas with homogeneous development patterns, isolating activities in separate TAZs assists in analyzing and measuring the behavior of different activities (Figure 2.24). Also, as shown in the Figure 2.24, at places where activities are concentrated on only one side of the TAZ, one can isolate trip generation from such activity easily by delineating the zones based on land uses. In the example depicted in Figure 2.24, by overlaying parcel land use data, one can visually understand that

Zone 609 has significant residential development (colored as yellow), and Zone 586 has very sparse development.



*Figure 2.24 Usage of Land Use Data to Analyze and Isolate Effects of
Different Kinds of Activities*

How to Use Homogenous Land Uses

One can use two primary data sources for the purposes of identifying existing or potential land use on a given parcel: (1) City's Master/Comprehensive Plan; and (2) County's Property Tax Appraisers parcel information. One can obtain master plans by contacting that particular city office. The plan generally contains maps depicting existing and future land uses for their jurisdiction. Most cities have electronic versions of these maps that one can use readily for the purpose. If the cities do not have an electronic version of these maps, one can either contact the county for the tax

parcel information or reference the land use maps geographically in software programs such as ArcGIS. The county's tax appraisal office collects information for each parcel to place a value on each individual property. One of several attributes collected is the current land use for each property. One can readily use this information in delineating TAZs, and it is typically available on-line.

Upon successfully obtaining the data from either of the datasets or any other source, one can delineate TAZ boundaries based on clusters of similar land uses

(Figure 2.25). One must use judgment to determine the logical groupings of land uses. It is not necessary to isolate each parcel with a distinct land use into a TAZ, but based on the required size of the TAZ, one can judge what constitutes a significant grouping of similar land uses. Figures 2.25a and 2.25b depict a few logical groupings of activities to delineate TAZ boundaries. In Figure

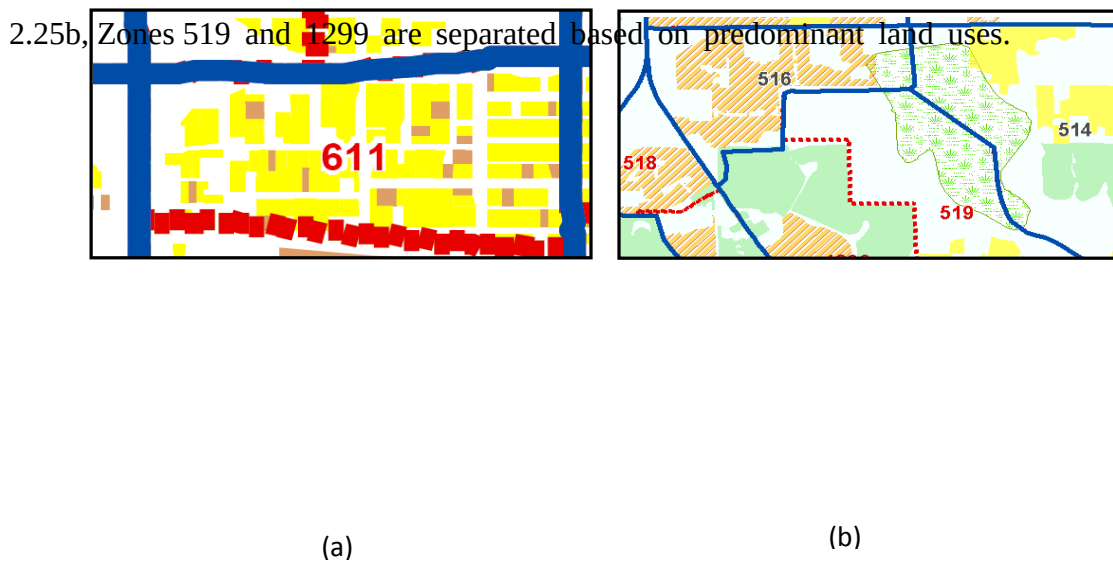


Figure 2.25a indicates the grouping of commercial activity into the zone 588 and predominant residential activity into zone 611. **Figure 2.25b** indicates grouping of predominant activity into zone 1299.

2.5.2 Special Generators

Special generators may be required when the normal trip generation equations produce extra productions or attractions, or produce fewer than expected for a specific trip purpose within a TAZ. These adjustments may be necessary if the trip generation rates applied to the socioeconomic data do not produce the correct number of trip ends. For example, parks and beaches normally have few workers and would produce very few attractions based on employment. By computing a value for the TAZ from some other source, such as the Institute of Transportation Engineers (ITE) Trip Generation Report, the planner can estimate a value for the recreation purpose.

Table 2.1 is a listing of special generators used in Florida.

Table 2.1: Examples of Special Generators

Common	Others
Universities	Hospitals
Community Colleges	Other Shopping Centers
Parks/Beaches	Government Buildings
Regional Shopping	Tourist Attractions
Military Bases	Ports
Airports	
External Stations	
Group Quarters	

For the purpose of delineating TAZs, one should keep special generators as separate zones. An example is a university in a mostly residential area. Centroid connectors coded within the special generator zone should represent the true access point(s) of the special generator to the surrounding roadway network. (Barton 1998).

2.6 ACCESS

2.6.1 Transit Access

A good estimate of transit ridership is sometimes directly related to a reduction in the size of TAZs. An ideal situation for travel demand modeling is to have zones as small as possible to minimize aggregation error.

This necessitates a mechanism to evaluate the percentage of the zone having the ability to walk to transit. This reflects the fact that, although transit service may directly service certain portions of the zone (via walk access), some of the zone may not be served at all. This mechanism is known as percent walk to transit or simply “percent walk.” The maximum distance is currently set to one-half mile.

Percent walks are carried into the mode choice utilities, expressed as different access markets. Smaller zones with good transit service are likely to be “100 percent walk,” when all activity has the ability to walk to transit. By contrast, large zones with isolated transit service are likely to be “25 percent walk.” Such zones are reflected in the mode choice model as 75 percent given only drive-transit and non transit modes, and 25 percent given a (marginal) chance of walking to transit and all other modes.

The PT Module

Zone sizes and connectors take on a heightened sensitivity with the conversion of Florida models to Florida Standard Urban Transportation Model Structure (FSUTMS) Cube-Voyager, as the Public Transport (PT) module strongly relies on a well-developed zone system with centroid connectors truly representative of access/egress capabilities. The new transit standards, recently developed by FDOT, use PT to generate all walk- and transfer-access connections (or access legs). Unlike its TRANPLAN-oriented predecessor, PT uses only the centroid connectors when generating the access legs. The new one-half mile maximum for walk-access effectively requires that zones served by transit need to have connectors less than one-half mile. Zones with longer connectors are not connected to transit, regardless of the frequency of the transit service. Figure 2.26 shows two zones (463 and 568) with hourly bus service. However, PT will not create any walk-access legs, because all the connectors for both zones are longer than one-half mile.

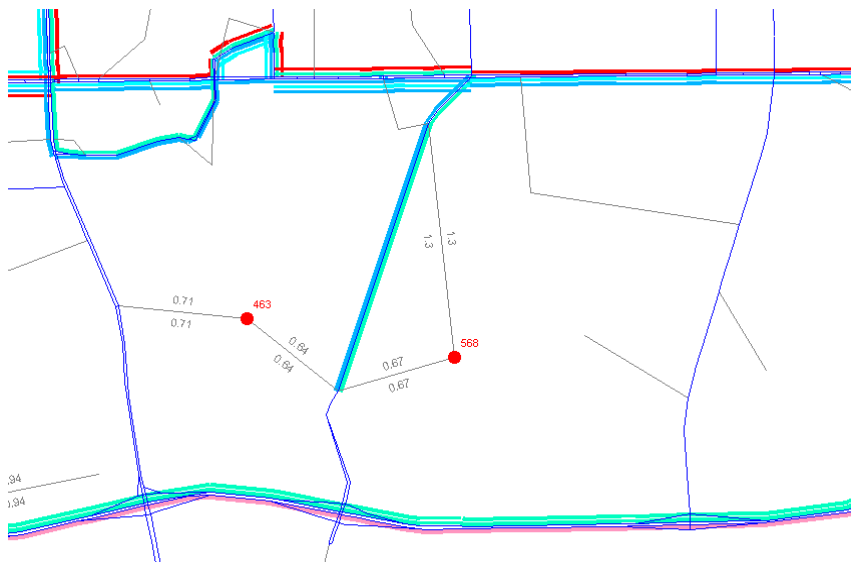


Figure 2.26 Two Zones with Bus Service, But Excessive Connector Length

Prevents Walk-Access Connections

The following two sections describe common problems that arise during forecasting studies when zone areas are not properly sized for the desired level of analysis. The final section describes an easy method to evaluate the effectiveness of zone sizes. Note that an individual examination of transit service and connectors for each zone is the best way to determine when they are too large for transit analysis.

The “Large Zone/Single Station” Problem

Figures 2.27 and 2.28 provide a good example of how large zones can impact transit accessibility and ridership. They represent a situation that arises in Alternatives Analysis called the “large zone/single station” problem. A large zone on the fringe of the suburbs contains one large development located in a quadrant of the zone. Assume no other development exists. The left side of Figure 3.12 shows a rail station (shown in red) on the western zone boundary. The percent walk computation determines that one-third of the zone is within one-half mile to the station. Although the development is more than one-half mile away, the mode choice model is told that 33 percent of the developments residents have walk access to transit. As a result, the transit market is 33 percent of the developments residents. The right side of Figure 2.27 illustrates the same conditions, but a subzoning process has been completed. In this case, the percent walk computations determine that 0 percent of the development’s zone has access to transit. The effective transit market is 0 percent, which is a more accurate representation.

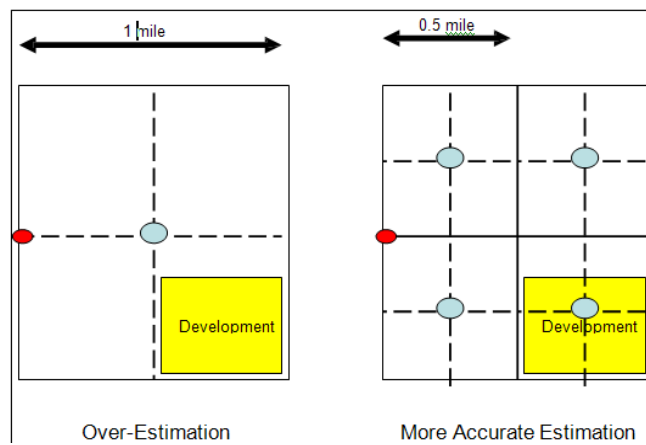


Figure 2.27 **Overestimating Walk Access to Transit**

Figure 2.28 illustrates the same zone and development assumptions, but with the rail station much closer to the development. The left-side conditions would result in the transit market underestimated. Assume the entire development is within one-half mile of the station. The percent walk computations would determine that only 33 percent of the zone is near the station. So the transit market is underestimated by two-thirds. The right side of Figure 2.28 illustrates a much more accurate estimation of the transit market, as the percent walks and actual distance to the station should match exactly.

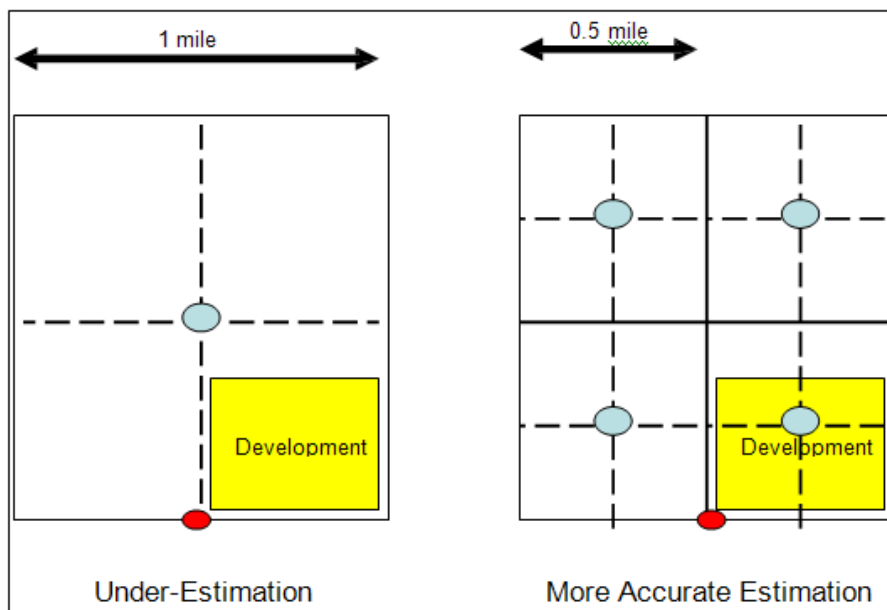


Figure 2.28 Underestimating Walk Access to Transit

A similar example is illustrated in Figure 2.29. Using Google satellite imagery, the larger zone assumes that anyone living or working in the TAZ has access to the transit stop on the western boundary since the centroid connector is less than 0.5 miles long. However, in reality, those located on the eastern side of the TAZ, as well as those located on the northern and southern sides of the TAZ, are not within a 0.5-mile walking distance. Additionally, the example assumes that people are walking across the lake which obviously is not the case. The Right Way, also illustrated as part of figure 2.29, demonstrates the correct way to delineate TAZs based on transit access, as people are not crossing the lakes to get to the transit stop. In addition, it does not assume the larger number of people have access to transit based on the distance of the centroid connectors within each TAZ. Barriers can also be coded separately in the barriers file to eliminate the possibility of transit access connectors being generated across these barriers.



Fig 2.29 Right and Wrong Way Delineate.

Zone sizes are also important for large parcels having a relatively small activity area that receive transit service. Airports and universities are classic examples. Figure 2.30 shows an example of this problem. Zone 463 is largely university property with a small area of concentrated activity. The activity area is within the black circle in the figure. A bus enters this zone and circulates within the activity area. However, since the zone is quite large, the bus routing cannot be better represented, and the transit market is underestimated for similar reasons as in previous examples.

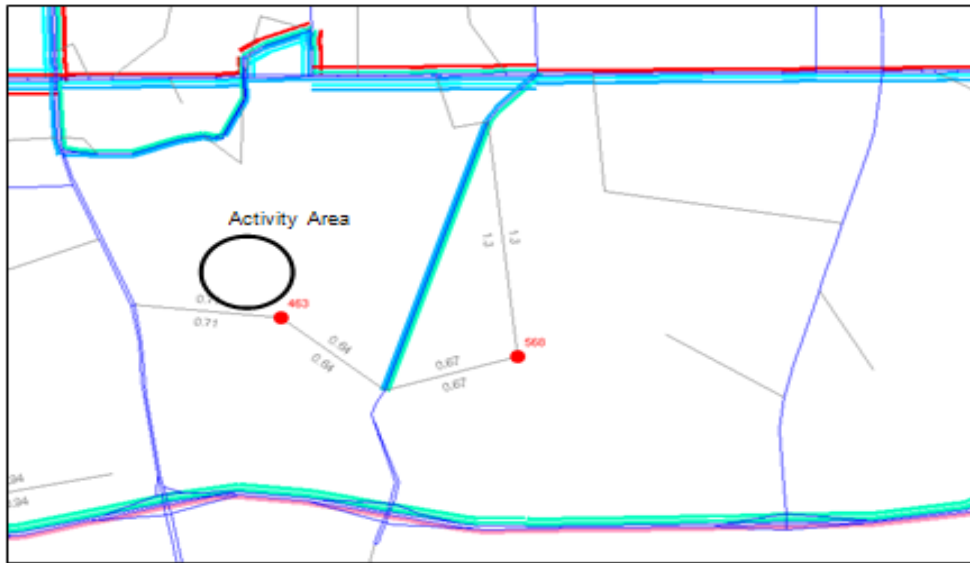


**Figure 2.30 University in Zone 463 Suffers from the Large
Zone/ Small Activity Area Problem**

Figure 2.31 shows a good example of how to correct this problem. In the Orlando model, the two major terminals of the Orlando International Airport (the entire property is bounded by a black rectangle) are given separate zones. Transit service to the airport can be coded very accurately, circulating through the microcoded streets and stopping only at the terminals.

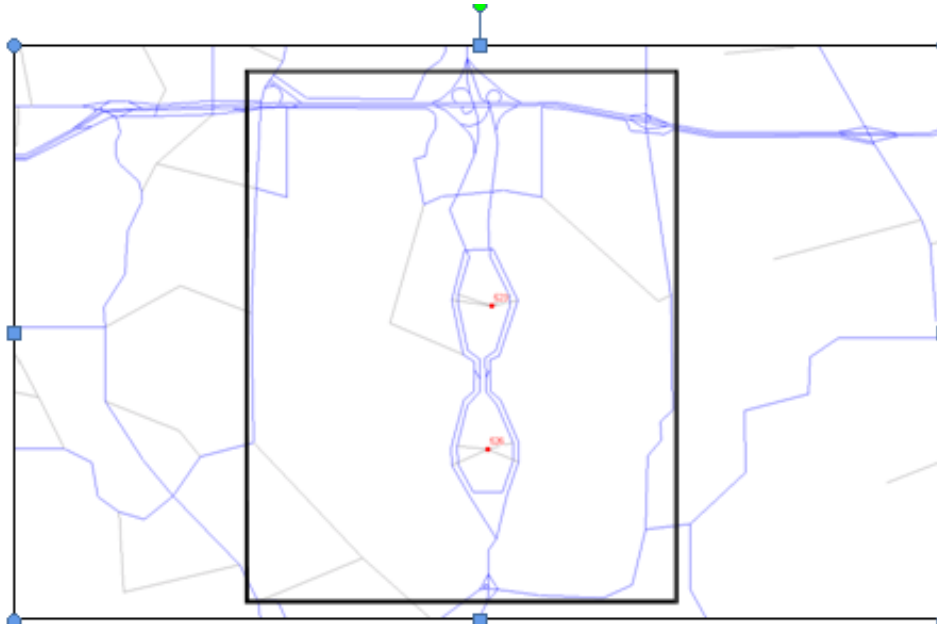


Figure 2.31 Good Solution to Large Zone/Small Activity Area Problem

Evaluating Zone Sizes

Zone sizes should be relative to the amount of activity being represented. However, gauging zone size and activity levels can be difficult, especially for future years when growth levels are abstract. A simple evaluation measure is to compare base and future year trip activity to zone size on a cumulative frequency distribution plot.

An example of the final plot is shown in Figure 2.32. From a transit perspective, all three lines should be close together and a majority of the zones should be less than a square mile. Figure 2.32 illustrates that slightly less than 50 percent of the zones are less than one-half square mile. Base and future year activity levels are divergent from zonal area. Only about 55 percent of base

year activity occurs in zones less than a square mile. Approximately 42 percent of future year activity occurs in the same zones. The results indicate that zone refinements are desirable.

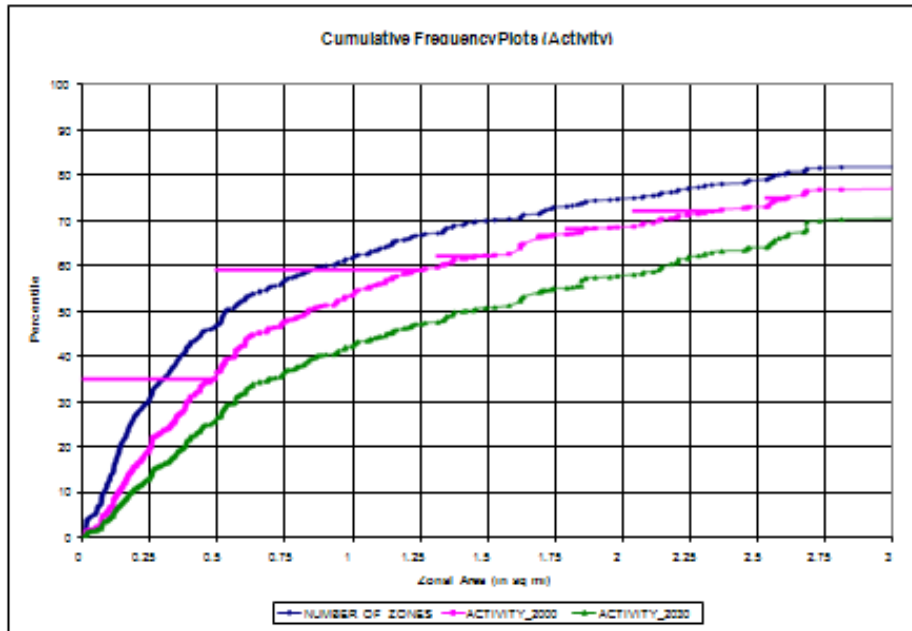


Figure 2.32 Graph Comparing Zone Size to Activity Levels

Figure 2.33 is the same plot for a different modeling area, the latest version of the Southeast Florida Regional Planning Model (SERPM). This graph implies a good zone area-activity balance, as over 90 percent of the zones are less than a square mile. Activity levels for the base and future years correlate very well with zone area.

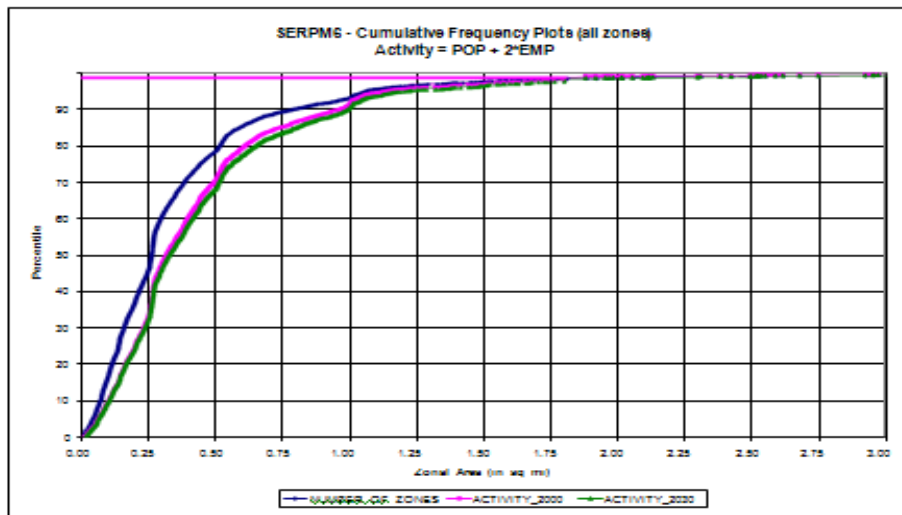


Figure 2.33 SERPM6 Graph Comparing Zone Size to Activity Levels

2.6.2 Freight/Intermodal Needs

Using methods included in the Federal Highway Administrations (FHWA) Quick Response Freight Manual, one can calculate the number of commercial vehicle trip ends by TAZ. The following facilities typically generate and attract a large amount of daily truck activity:

Seaports;

River docks;

Truck-rail intermodal terminals;

Airports;

Major manufacturing plants; and

Wholesale, retail, warehousing and redistribution, and extractive industry sites (dependent upon the level of freight/truck activity).

It would be ideal to isolate these truck generators/attractors into separate TAZs.

Office of Freight Management and Operations, Federal Highway Administration.

The FHWA Freight Analysis Framework (FAF) data provides commodity flow estimates between states, regions, and major international gateways. FAF provides commodity flow estimates for 2002 and the most recent year plus forecasts through 2035 and addresses seven modes: truck, rail, water, air, intermodal, pipeline, and other multiple modes. As an alternative to the FHWA Quick Response Freight Manual method, TRANSEARCH data is often used to convert the FAF commodity flow data to commercial vehicle trips. The old version, FAF¹, provided commodity flow data at the county level. However, the new version, FAF, provides data at the Commodity Flow Survey (CFS) zone level. As illustrated in Figure 2.34, there currently are 114 CFS zones in the United States, five of which are in Florida (statewide, Jacksonville, Tampa, Orlando, and southeast Florida). The FDOT currently is disaggregating the FAF data further into smaller freight analysis zones (FAZs) for the state of Florida. It is anticipated that these FAZs will be based largely on the current year 2000 Florida Statewide Model TAZ structure. It is recommended that modelers consider the statewide model TAZ structure not only for the purposes of being consistent with the FAF zone geography, but also to assist with delineating TAZs in more rural areas.

In addition, some areas in Florida, such as Tampa and Orlando, have collected local truck trip-making data to use in their truck models, as the level of aggregation in the Florida Statewide Model may not suit their needs. One should use local freight/truck data, if available, instead of the statewide model truck data. However, note that although many areas may have collected local truck count data, truck count data alone is not sufficient to develop truck trip

patterns in a truck model. A truck trip diary survey is necessary to calculate truck trip attraction rates and replicate truck trip-making patterns.

Office of Freight Management and Operations, Federal Highway Administration, Florida Model Task Force Meeting, December 2006.

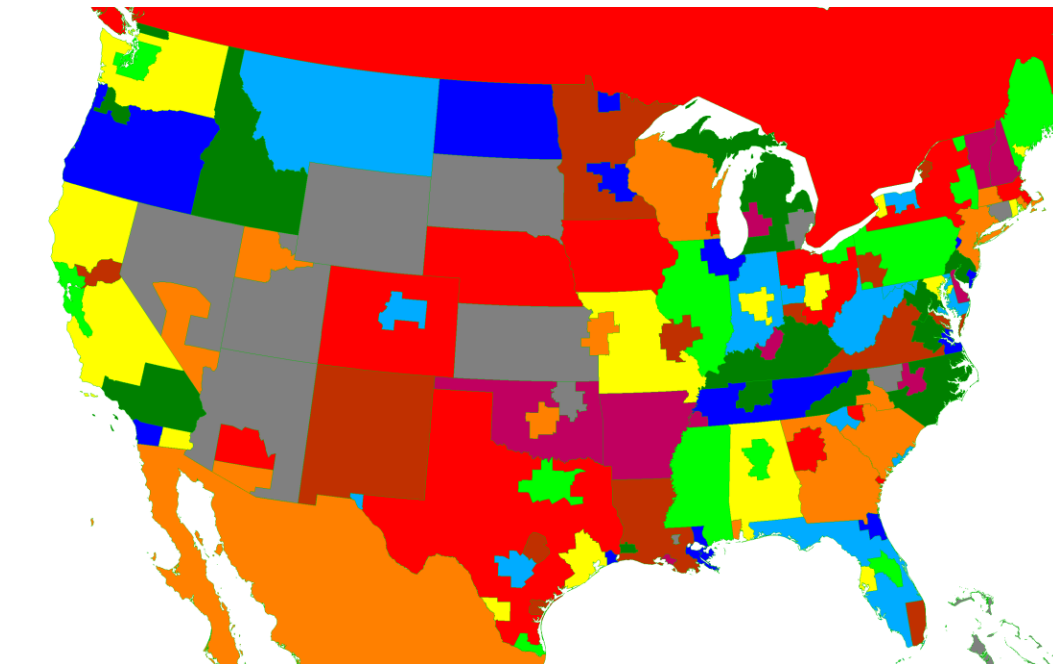


Figure 2.34 Freight Analysis Framework CFS Zones

Source: Office of Freight Management and Operations, Federal Highway Administration.

2.7 CENTROID CONNECTORS

In addition to defining the actual boundaries of TAZs, representing realistic access to and from the zones with the use of centroid connectors is also important. The following is a summary of guidelines already discussed that one should consider when coding centroid connectors:

Centroid connectors should represent realistic roadway and transit access;

Centroid connectors should not cross man-made or natural barriers, such as lakes, rivers, railroad tracks, limited access highways, etc.;

Include a sufficient number of centroid connectors to avoid the loading of too many trips onto one roadway network link;

Do not connect centroid connectors at intersections or directly to interstate ramps, as illustrated in Figure 2.35a (The Wrong Way) and Figure 2.35b (The Right Way); and when two centroid connectors are connected to the same roadway segment, the access points should be separated by a certain distance, as illustrated in Figure 2.36a (The Wrong Way) and Figure 2.36b (The Right Way).

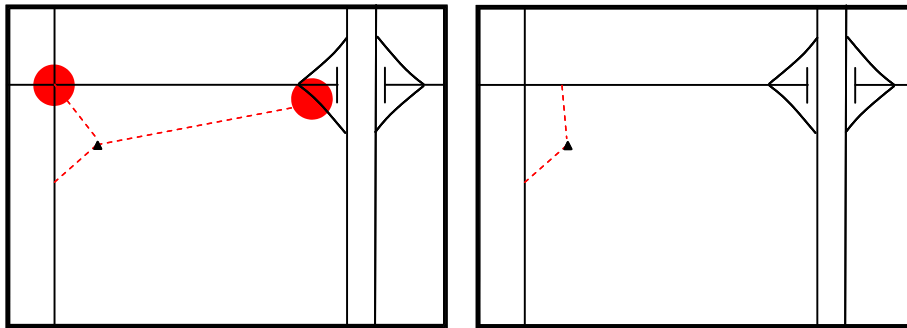


Figure 2.35 Placement of Centroid Connectors Relative to Intersections and Interstate Ramps

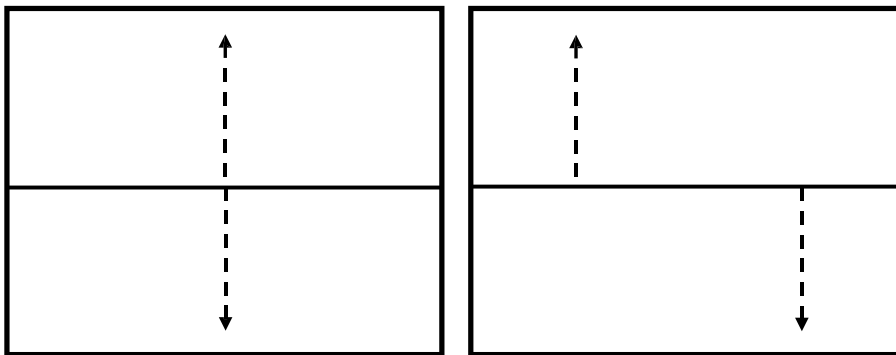


Figure 2.36a The Wrong Way
(a)

Figure 2.36b The Right Way
(b)

Figure 2.36 Offsetting Centroid Connectors at Access Points

2.7.1 Existing Transportation Facilities

Much like physical geography, the location of existing transportation facilities is among the most common considerations for TAZ delineation. In terms of high- way facilities, only freeways, expressways, and arterials are considered access barriers, as local and collector streets do not

necessarily restrict movement across them. Even for major roads, understanding grade separations is helpful in determining and potentially filtering out the street segments that might impose physical barriers. Data on minor roads, though they do not provide barriers, can be useful in determining whether or not any access is possible from a given TAZ to the model network (earlier Figure 2.17c).

The following transportation facilities should always form TAZ boundaries:

Rail lines; Limited access highways; Arterial streets and roadways; and Collector streets and roadways.

Matching the boundaries of TAZs with roads assists in more accurate loadings of trips onto each street segment, and minimizes coding of centroid connectors that cross over major roads. Having the knowledge on how minor roads link to major highway facilities is useful in determining logical boundaries for TAZs. In the earlier figures, delineating four separate TAZs based on underlying roads isolates the effect of the area serviced in each quadrant on the model network; however, TAZ splitting, as displayed in Figure 2.18c, would only be necessary if this were a location of high-density development.

One-way streets provide a different set of challenges in delineating TAZs. If major one-way streets are used as TAZ boundaries, this results in somewhat small zones lying between the two parallel streets that comprise a one-way pair. One-way streets are often present in CBDs. In the interest of minimizing streets bisecting zones, some CBDs have separate TAZs for every downtown block. The downside of this is that persons often park in a different zone from where they work, causing some inaccuracies in highway modeling. Conversely, transit modeling requires access from the buildings.

2.7.2 TAZ Numbering

Although not required, it is recommended that TAZ numbers begin with one and be consecutive. However, it is not uncommon for regional models to set aside a specific range of TAZ numbers for both TAZs and dummy zones for each county. For instance, County A may use numbers 1 to 100, of which 81 to 100 are dummy zones. County B may use numbers 101 to 200, of which 171 to 200 are dummy zones. This allows the model users to differentiate between counties or other political boundaries. Another way to flag counties is through the location code, which is often used in Florida. Other areas throughout the country may actually sequence the zone numbering within and outside the CBD or along a perimeter roadway (i.e. beltway).

In addition, one should create TAZ equivalency tables to provide a list of the new zone numbers that were split from the original zone numbers. One can use these TAZ equivalency tables to further aggregate or disaggregate the corresponding socioeconomic data.

2.7.3 Future year TAZ Considerations

In addition to reviewing existing data, future year data should also be considered when delineating base year TAZs. Once the base year TAZ structure has been finalized and the model validated future year socioeconomic data and trip forecasts should be reviewed as part of model sensitivity testing. It is important that TAZ boundaries and centroid connectors generally remain the same between model years with a few exceptions, as changing them impacts the model validation. These exceptions include the following:

Future planned transportation corridors (both highway and transit);

Developments of regional impact (DRIs); and

Construction within previously vacant areas that would result in increased densities.

Further detail is provided below.

2.7.4 Planned Transportation Corridors

When defining the TAZ structure in the base year, one should also consider planned future transportation corridors. The Long-Range Transportation Plan (LRTP) for the study area should be used to identify planned highway and transit corridors. If a planned highway or transit corridor bisects a TAZ, the modeler should consider splitting the TAZ in the base year if feasible. Figure 2.37a provides an example of how the base year zone structure and centroid connectors may look without considering a future corridor. Figure 2.37b illustrates what the base year zone structure would look like if the planned corridor were considered; however, the future corridor is not depicted in the base year network. Figure 2.37c illustrates the future year zone structure with both the planned corridor and additional centroid connectors included. One can consider this same process when conducting subarea studies that require further refinement within the travel demand model.

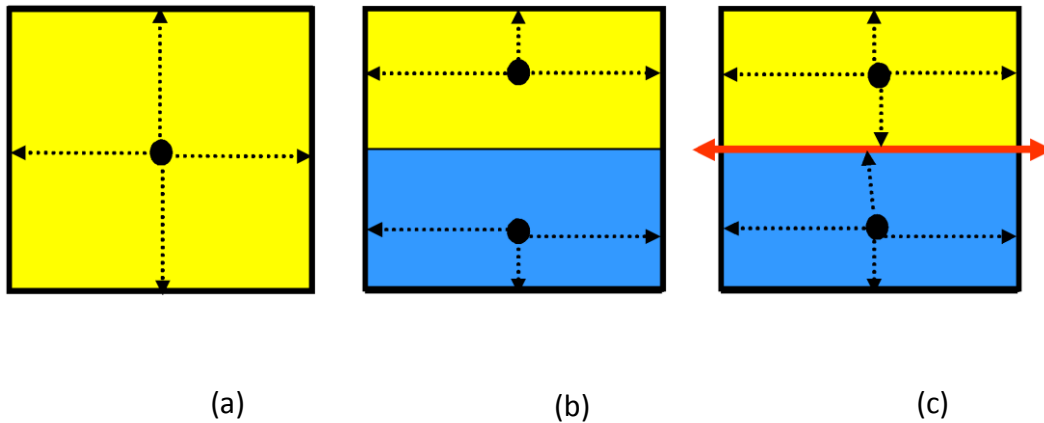


Figure 2.37a – Base year zone structure Figure 2.37b – Base year zone structure Figure 2.37c – Future year zone structure

2.7.5 **Developments of Regional Impact**

In addition to network changes, one should also consider future socioeconomic data, especially new DRIs in the study area. The modeler should consider the study area's Comprehensive Plan future year land use map and any amendments when delineating TAZs in the base year, as it can have a significant impact on the delineation of TAZs.

2.7.6 **Population and Trips Per Zone**

As mentioned earlier anything more than 15,000 trips per day or 1,200 to 3,000 people per TAZ exceeds the recommended zone size. Often times, a TAZ may not have as many people or generate that many daily trips in the base year.

However, with the future year land use, it may very well push the population or daily trips over the thresholds noted above. As a result, one should also consider future year socioeconomic data when delineating base year TAZs.

2.7.7 Network Data Impacts

As discussed in earlier when one splits a TAZ, one needs to update the highway network to reflect the new TAZ structure. For instance, one may split a TAZ as a result of a minor arterial road being added to the model that now bisects the zone. The minor arterial that split the zone now serves as the new border of two split zones. Note that in some cases, adding a link in the highway network to reflect a new road or additional network detail may require the splitting of a highway link. If the model also includes a transit network, the user should activate the transit route files in FSUTMS-Cube Voyager in order for the transit route files to be automatically updated if the link being split occurs on a transit route. If the split link occurs on a transit route and the transit route files are not updated, the transit step fails when running the model as a result of the erroneous node sequencing in the transit route file due to missing node(s). In addition to updating the highway network roadway links, centroid connectors also require updating as a result of new TAZs or TAZ splits. Centroid connectors should represent realistic access points.

2.8 SOCIOECONOMIC DATA IMPACTS

2.8.1 Household Data

Splitting household data into new TAZs can be the most time-consuming aspect of zone splitting, dependent upon whether TAZ boundaries are consistent with Census or political geography. Having TAZ boundaries consistent with Census geography enables practitioners to readily access the Census data for apportioning the data after a TAZ has been split. If the boundaries are not

consistent, the process might be tedious and may require local-area knowledge to apportion the data properly.

As mentioned earlier in this research, the U.S. Census Bureau only collects household data on a decennial timeframe, although each state's clearinghouse agency estimates and forecasts county-level population for a number of future years. The Bureau of Economic and Business Research (BEBR) at the University of Florida serves as Florida's official agency for population projections.

The data elements that the Census Bureau collects vary for different Census geographies.

At the block level, the Census Bureau collects and tabulates 100 percent decennial Census data. At the block geographic level, one can obtain information on age, number of households, and whether the residence is owned or rented. The Census Bureau collects this information from all people and housing units in the Census SF1 and SF3 databases. In terms of household data for modeling purposes, though information on population and dwelling units is offered at the block level, details such as the type of dwelling unit (single-family or multifamily) and population levels for each type of dwelling unit, are not available. The Census Bureau provides these details at the block group level, at which the Census Bureau tabulates sample data from the decennial Census. The Census Bureau collects the sample data from one in six people, and then weights the sample data to represent the total population. Block group data contain additional information on population and housing, including auto availability and income.

In cases where the new zone structure (after TAZ splits) is consistent with Census block groups, data for the new zones can be derived directly from the underlying block groups without exceeding the totals of the original zone's data. Although the new zone structure is consistent with the Census block group structure, the relative proportions must be derived from the Census block group data rather than directly using the Census data itself. This is as a result of the base

year in question not being the same as that of Census data. For example, assume that Zone 425 has a population of 1,000 and is split into three zones, renumbered as 425, 495, and 501, and the geography of the new zone structure matches that of the Census block groups (Figure 5.1a). Based on the Census block group data, one can compute relative proportions for all three new zones using the following formula:

Relative proportion of population for zone 495 (Pr_1) = Population in the block group that new zone 495 corresponds to / Total Population of all block groups that correspond to original zone 425. These proportions can then be applied to the original zone's data to derive data for the new zone structure. In our example, population for new zone 495 will be equal to $1,000 \times Pr_1$. Upon assigning data to these new zones, it is important to verify that the total from the new zone structure is equal to the original zone's data. As we are applying proportions to the original's total, there may be instances where there is a loss of data due to rounding errors. For example, the total of the original zone 425 may be 1,000, whereas the total from the new zones 425, 495 and 501 may be 1,001 due to the rounding errors from calculating the United States Census Bureau Proportions. Hence, verifying the totals after assigning the data based on relative proportions is important.

One can adopt a similar process described above in instances where the new zone structure does not match the block group geography but it does match block geography. One can derive data for the new Zones 425 and 495 (as illustrated earlier), which are consistent with block geography, using relative proportions of general household data from Census blocks (rather than block groups) and one can apply the remaining portion of the original zone's data to 501. There might be situations where TAZ splits are inconsistent with all Census geography.

In such cases, one can use alternate data sources that provide information on land

uses (e.g., parcel data), in addition to Census data. In many cases, one must use deductive reasoning to identify the most likely distribution. There might be a scenario where the split intersects one or more block geographies. In such instances, one can use land use and parcel information over and above the mathematical operations to make best judgments on household data distributions over these multiple block geographies. Only the dwelling unit and population data were split according to the above methods.

2.8.2 Employment Data

Splitting employment data might not be as complicated as household data, as long as employment is available in latitude/longitude. To split employment data, one needs a dataset similar to the Census that provides employment information by various industrial sectors, such as InfoUSA.

InfoUSA is a proprietary database that provides spatially enabled employment data (latitude/longitude information) with information related to the classification and size of the business establishments. FDOT purchased 2007 InfoUSA data for the entire state of Florida and intends to distribute these data to each of the FDOT district offices for public-sector use. Each business establishment in the InfoUSA dataset is flagged with both a Standard Industrial Classification (SIC) code and a North American Industry Classification System (NAICS) code specifying its industry classification.

The Standard Industrial Classification Code is a four-digit code used to categorize various employment industries. The official listing and descriptions of these codes are available on the Securities and Exchange Commission's web site at: <http://www.sec.gov/info/edgar/siccodes.htm>.

The North American Industry Classification System (NAICS) Code is a six-digit code used

to categorize various employment industries, which was released in 1997 and has since replaced the SIC code. The official 2002 U.S. NAICS Manual, which includes definitions for each industry and tables showing the relationship between 2002 and 1997 NAICS codes that were changed, One can use these classifications to identify the type of employment, such as industrial, retail, or service, that are needed for allocating industry-specific employment data input into the travel demand model.

In addition to providing SIC and NAICS codes for each establishment, the InfoUSA database also provides information with regard to the size of the establishment. This information is provided on a categorical scale in Table 2.2

Table 2.2: InfoUSA Categories for Number of Employees

Code	Number of Employees	Code	Number of Employees
A	1 to	G	250 to 499
B	5 to	H	500 to 999
C	10 to	I	1,000 to 4,999
D	20 to	J	5,000 to 9,999
E	50 to	K	10,000 or more
F	100 to		

Though InfoUSA does not provide the exact amount of employment for all employers in the InfoUSA database, one can use median values in these ranges to derive approximate employment at each establishment. The InfoUSA dataset provides the data elements, employment type, and size that are required for the TAZ splitting process. One can also use any other dataset that provides similar information, assuming it is comparable to the InfoUSA data.

For splitting the employment data, each new zone should be geographically overlaid with the master employment data (i.e., point locations from InfoUSA). Based on the employment

classifications required by the travel model, one must aggregate data for all locations that fall inside any new TAZ for each of the classifications to obtain total employment by industry in each zone (see Figure 2.38). One can use this information to derive relative proportions of employment using the employment database. One can then apply these relative proportions to the original zone's employment data to obtain data for all new zones.

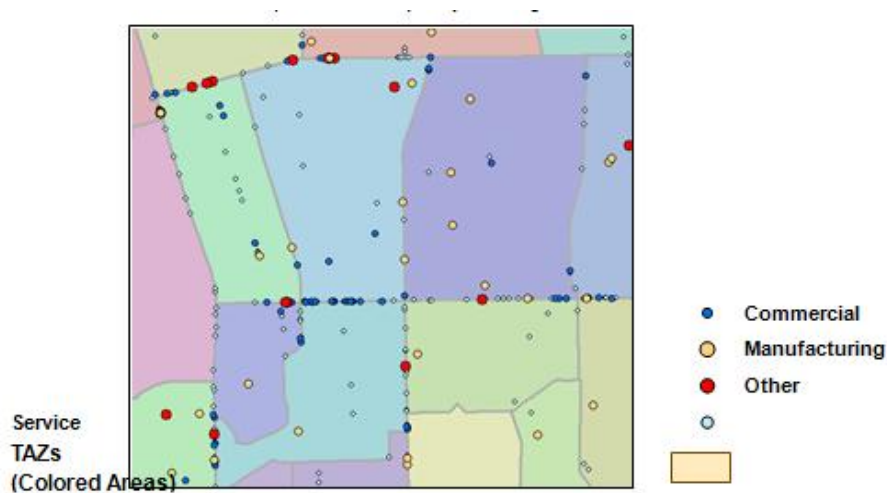


**Figure 2.38 Master Employment Data Categorized Into Classifications
(Colour-Coded) Required by the Model**

For example, original Zone 425 was split to obtain three new zones that were numbered as 425, 499, and 501. For a spatial overlay of master employment data onto these new zones, 50 employees in the manufacturing sector might yield estimates of 12, 20, and 18, respectively. One would then use these values to obtain relative proportions as:

12 InfoUSA Employees/50 Total InfoUSA Employees = 0.24 or 24 percent of Original TAZ 425; 20 InfoUSA Employees/50 Total InfoUSA Employees = 0.40 or 40 percent of Original TAZ 425; and 18 InfoUSA Employees/50 Total InfoUSA Employees = 0.36 or 36 percent of Original TAZ 425.

If the original TAZ had a total employment of 60 in the manufacturing sector, then employment is allocated by conducting the following computations:

0.24×60 Original TAZ Employees = 14 Employees in New TAZ 425;

0.40×60 Original TAZ Employees = 24 Employees in New TAZ 499; and

0.36×60 Original TAZ Employees = 22 Employees in New TAZ 501.

One can write scripts using Visual Basic for ArcGIS to automate the methodology of splitting the employment data and for quality control processes, thus saving significant time and effort in manual computations.

2.8.3 Other Data Element

Besides household and employment data, there are other data elements that need to be distributed during a TAZ split process. Some of these elements include schools, hotel/motel units, and special generators, such as universities, DRIs, or regional shopping malls. The methodology for all these data elements is grouped under one heading, as there are no universal datasets that would facilitate these data splits. Data splits for most of these elements would require human judgment beyond the use of available data.

Travel demand models typically require total school enrollment by school location. Some models may even require additional details in terms of different types of schools, such as primary school, high school, colleges, and school zones. Unlike the Census and Info USA, it might be challenging

to obtain a school data- base with all the required information. If a geographic file encompassing all school data is available, then one can follow a procedure similar to that of splitting employment data. One can overlay the master school data with the new zones resulting from the split, and data in each new zone can be aggregated and classified by the type of school (if that data is available) to obtain school statistics for each zone. One can then derive relative proportions based on master school data and applied to each zone's data. In most cases, the density of school locations is less than that of employment data locations.

Sometimes a simple visual analysis of geographic data can assist in splitting the school data. As shown in Figure 2.39, if Zone 265 has to be split at the red-dotted line, then through visual analysis, one can easily attribute all school data to the bottom half of the TAZs, where the all schools seem to exist. If the model area is considerably small, then one can even consider obtaining a list of school addresses from the State's Department of Education and geocoding these addresses to locate them geographically. If no school data are available or if the accuracy of the available data is questionable, then land use data can be obtained from the City or County's Comprehensive Plan, or from the tax appraisers office (Figure 2.40), to locate zones where schools may exist based on education or institutional land uses. Local knowledge of land use can definitely assist in conducting visual analysis and deciding how the school data needs to be split.

Similar to schools, models require information related to number and occupancy of hotel/motel units. Geographic data on hotel/motel units are much more tedious to obtain from a public source than that of schools. If such data are directly available, then a procedure similar to that explained for schools can be used. If such data are not available, then one might consider using Info USA data (based on Industrial Classification codes) or geocoding sites (as in schools); or even searching

through map engines, such as Google Maps or Yahoo Maps, to identify locations of hotels/motels in a given area. Though these might not be the most efficient processes, these sources often provide valuable information. The information provided on some of these web sites link to the actual hotel web sites, wherein information related to number of rooms is readily available. In either case, land use information can further assist in visually locating zones that may contain all

or none of the hotel/motel land uses and distribute data accordingly. For example, in Figure 2.5 below, parcel data, symbolized according to its land use, violet being hotel/motel units, is overlaid with the zones. If a split is being proposed at the red-dotted line on Zone 454, underlying land use data helps in identifying that all the hotel/motel units would end up in the bottom half of Zone 454.



Fig 2.40:

Parcel Data Overlaid with TAZ Boundaries



Fig 2.39

Schools Overlaid with TAZ Boundaries

Special generators relate to any major activity center that can potentially generate a large number of trips. Generally, these generators include major universities, regional shopping malls, DRIs, etc. Geographic data on these facilities may not be readily available, but is very easy to generate. As there is a minimal number of such facilities in a given model area, when compared to schools or hotels, obtaining information on these facilities should not be as time consuming. Most of these facilities should be well known and can be mapped with ease.

Information regarding DRIs is generally available from city/county or regional planning council web sites. As the number of these generators is fewer, it is best to visually identify them and assign the data accordingly. It is not typical that a given TAZ would have two special generators, and hence the process of relative proportions may not be required here. In cases where there are multiple generators located in a single zone and that zone had to be split, then one can obtain or assess data on the sizes of these generators based on professional judgment/knowledge to determine the distribution. Again, as with the other two data elements, one can use land use information in conjunction with any available data to make an informed decision.

2.8.4 Handling Boundary Shifts and Zone Aggregations

Besides simple zone splits, there might be instances where the zone refinements include boundary shifts, zone aggregations, or sometimes a combination of splits, shifts, and aggregations. The methodology of distributing data in such an instance can sometimes be a challenging task. As discussed earlier, the complexity of this process depends on how well the model data geographically corresponds to any external datasets, such as the Census, InfoUSA, or

others.

Boundary Shifts

A shift in the boundary of a TAZ may be necessary for several reasons. Primarily, if the existing boundary of a TAZ does not correspond completely with the Census, political, or any other relevant geography, and if through slight modification to the TAZ boundary, the TAZ can be better represented in terms of travel characteristics, then a boundary shift is most relevant (see Figure 2.41). Figure 5.6 provides an example where one must alter the boundary to include all residential activity (in green) into one TAZ (505). Splitting the TAZ would result in tiny TAZs of no significant meaning. A boundary shift is extremely helpful, especially if the model has constraints in terms of total number of TAZs, as a boundary shift does not require any additional dummy zones to be used.

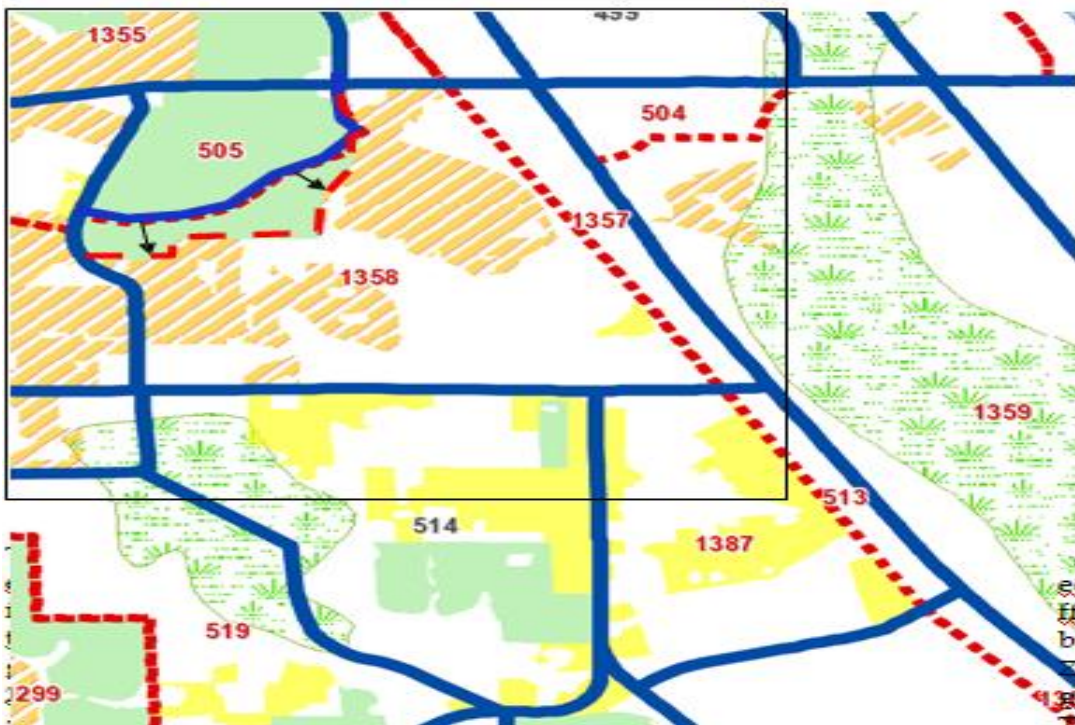


Figure 2.41 Land Use Data Overlaid with TAZ Boundaries to Demonstrate a Scenario Where Boundary Shift May be Valid

Based on a combination of relative proportions, human judgment, and land use data, as explained in the TAZ splitting section, data from the larger zone (2000) can be split into its constituent zones. In our example, if the population for Zones 276, 283, and 299 is 100, 100, and 100, respectively, the larger zone has a population of 300. We would then compute the relative proportions based on the new zone boundaries. In this example, that results in the following proportions: 0.1 for TAZ 276; 0.6 for TAZ 283; and 0.3 for TAZ 299. The data distribution is as follows:

0.1×300 Original Population = 30 People in New TAZ 276; 0.6×300 Population = 180 in New TAZ 283; and 0.3×300 Population = 90 in New TAZ 299.

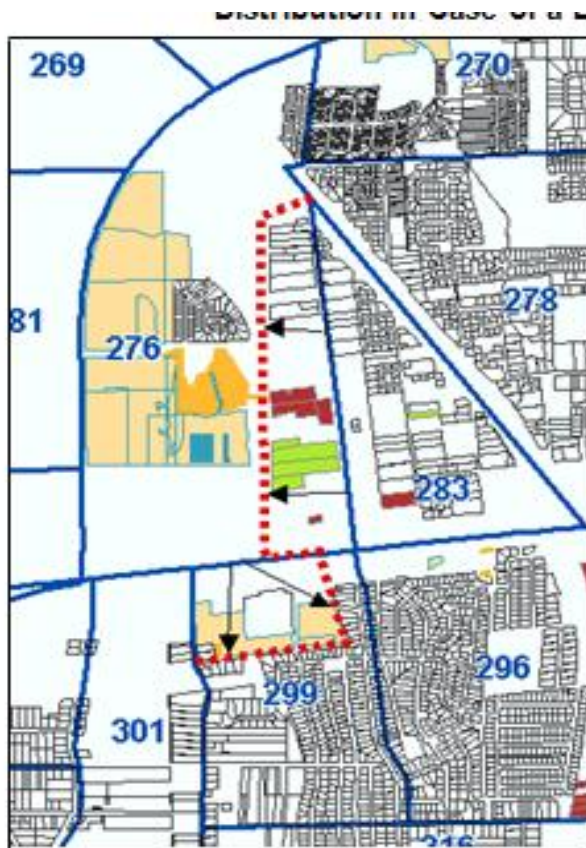


Figure 2.42 Parcel Data Overlaid with TAZ Boundaries to Demonstrate Data Distribution in Case of a Boundary Shift

Zone Aggregations

Aggregation of zones is sometimes required when a given zone area is much smaller than what is necessary for purposes of the model. In other words, if any given zone does not have distinct travel characteristics from that of its neighboring zones, then a zone aggregation could be a valid process. Also, as in the case of boundary shifts, zone aggregation does not consume any additional zones and, in fact, results in the creation of a new dummy zone that can be used at any other relevant location in the model area. As a result, if zone splits are needed in one part of the model (e.g., downtown) to better represent travel patterns, and the model has a limited number of available dummy zones, one may conduct zone aggregations in less dense areas to free up additional dummy zones that are necessary for zone splits elsewhere in the model.

The process of distributing data for zone aggregation is fairly straightforward. The methodology constitutes a simple data aggregation of all the zones involved in the aggregation process. In the example shown in Figure 2.42, if Zones 286 and 287 need to be aggregated, then the data are simply added together. If the new zone, shown in yellow, is assigned the number 286, then the Zone 287 is now available for usage at any other location in the model area.

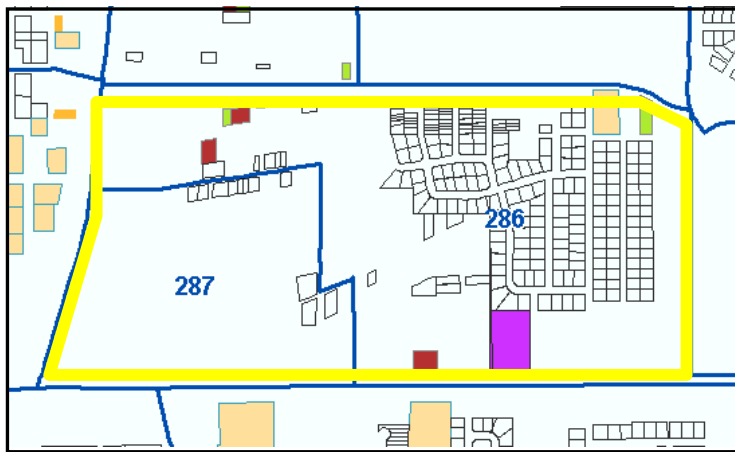


Figure 2.43 Parcel Data Overlaid with TAZ Boundaries to Demonstrate

Aggregation Process

Situations might arise wherein one must conduct multiple refinements, such as splits, shifts, and aggregations. In such instances, one can readily adopt procedures previously explained for these individual processes. Using Figure 2.43 as an example, Zones 276, 283, and 299 need to be aggregated and split to form new Zones 276 and 283. To redistribute the data, all attributes from these three zones must be first aggregated and then using processes described earlier, split the data from this larger zone into Zones 276 and 283. If a boundary shift is needed for Zone 283, the data from new Zones 276 and 283 then needs to be aggregated and split accordingly.

2.8.5 Zones Beyond Model Boundary

Model boundaries are periodically expanded to incorporate additional counties and other transitioning areas. In many cases, this involves adding areas to the model that do not already have TAZs designated. Therefore, rather than splitting TAZs, one must develop new zones from scratch. Discussions earlier in this report provide sufficient guidance on considerations for establishing TAZ boundaries. Data availability is a significant concern in these new areas, so the initial boundaries should reflect readily available geographic divisions, such as Census block groups. Depending on

development density, it might be acceptable to have larger-sized TAZs in outlying counties.

2.8.6 Revalidation

Once the TAZ structure has been refined, one must revalidate the model against the original model to ensure that the model is performing as well as or better than the original model. One should compare statistics from each step in the model process, including trips per TAZ, trips per purpose, and intrazonal trips, at a minimum. As a reasonableness check, one should overlay the TAZ boundaries with freeways, bridges, water, railroads, military bases, etc. One should overlay TAZ boundaries with household, employment, population, and income data to verify patterns of homogenous land use are properly represented.

2.8.7 Effects of Traffic Analysis Zones Design on Transportation Models

Mobility need manifests itself by a trip between two points of territory anywhere located. A disaggregated analysis of these trips would produce insurmountable difficulties in modeling of the transportation system (T).

Infact, a systemic approach to the study of mobility, provides for the modeling of territory that unfold in two subsequent steps:

In the hypothesis of discretization of territory in zones and aggregation of origins and destinations of elementary trips by zone, it's possible to realize a modelization coherent with the analysis level and that can be analytically dealt with, through present computation resources. In a network model, each zone is represented with a single point (zone centroid). In it all trips' origins and destinations are located, which produce traffic flows among the zones (Meyer D., Miller E.J.,2001), and physical, demographic and socioeconomic variables useful to define the system of activities (A) (McNally,2000). Aggregation of origins and destinations of elementary trips by zone is not without consequences in analysis about system T, because in network models intrazonal trips are ignored. This implies an underestimate of trips' number of the study area with a

consequent underestimate of traffic flows on the network and effects on services' planning.

A recent distribution model (Cascetta, 1998) considers the presence of a multiplicity of elementary destinations within a traffic zone through introduction of a “size” variable ($\ln M_d$). In this model one zone (d) is considered as a compound alternative of choice. From the assumed hypothesis it derives a formulation of systematic utility of zone (V_d), which will be influenced by the number of the possible destinations being in the zone:

$$V_d = \sum_j \beta_j X_{jd} + \ln M_d$$

in which M_d is the number of elementary destinations of zone; X_{jd} is the j^{th} zone's attribute. It's evident, then, as the number, the shape and not last, the homogeneity of socioeconomic characteristics (SE) (expression of capacity to generate and to attract trips), produce effects on the outcomes of analyses of the system.

In this note, it has been carried out a quantitative evaluation about effects of different levels of aggregation of socioeconomic and demographic data into TAZs on outcomes resulting from the simulation of a transportation system, by proposing a methodology for the design of zone number and for the aggregation of basic spatial units into homogeneous zones.

In Section 2 is described the state of the art about both zoning methodologies and the influence of zoning utilized on model's results. In Section 3 is described the methodology adopted to solve TAZ design problem; it is also reported an application of the methodology applied to a real case with the analysis of the obtained numerical result; in section 4 are reported the conclusive considerations useful for following analysis and perspectives of research on this subject.

2.8.8 The State of the Art About Territory Modeling

The Zoning of a study area consists of two subsequent phases:

- Definition of spatial aggregation level of socioeconomic characteristics to achieve (determination of number of zones);
- Determining shape and dimension of the zones respecting the spatial aggregation level determined.

To determine the number of zones, Oppenheim (1995) asserts that no formal methods for defining the zones' system exist. Characteristics of these zones must be decided on empirical bases in every specific situation.

In general the number of the zones inside the study area is closely connected to the analysis' level that we want to achieve.

In short-term operations management programs, the number of zones to identify will be high. This will require the definition of a transportation network more detailed. In analysis of strategic problems a smaller number of zones, coherently with the supply model, is adopted (E. Cascetta, 1998; J. De D. Ortuzar, and Willumsen, 1994). Gehlke e Biehl already in 1934 had noted the tendency for correlation coefficients to increase with the level of aggregation of census tracts. Openshaw e Taylor (1979, 1981), Openshaw (1984), Fotheringham e and Wong (1991) have studied errors that can affect analysis based on aggregations of spatial data.

Openshaw (1977), in particular, presented a hierarchical heuristic procedure for Automatic Zoning Problem (AZP) by optimizing an objective function that was used to measure partition performance in terms of a predefined target value.

C. Ding (1998) analyzed impacts of socioeconomic data aggregation into traffic zones, at a national scale (South Korea), with gravitational demand models. He highlighted as the number of unsimulated intra-zonal trips is deeply affected from the number of zones especially when it is small. Ding deduced that exists a number of zones that isn't useful to exceed. In particular, with

reference to network congestion index, Ding has remarked that exists a value of the number of zones under which the results calculated are quite different from those obtained increasing zones' number. Moreover, Ding noticed that over another value there is a little change of this index.

To physically delimit the zones, the criteria generally adopted can be summarized in:

1. Homogeneity with respect to the socioeconomic characteristics;
2. Compactness of TAZs' shapes;
3. Respect of administrative limits as census sections, municipal borders, etc.;
4. Respect of physical geographic separators placed on territory as railways, rivers etc.
5. Exclusiveness (no doughnut).

The elementary units in which are spatially organized socioeconomic data (basic spatial units - BSUs) (You J., Nedović-Budić Z., Kim T.J., 1996) in Italy coincide with ISTAT (National Institute of Statistics) census sections.

Procedures to design traffic zones through the aggregation of BSUs, on the base of definite criteria, are numerous and generally follow cluster analysis.

To aggregate two BSUs, their contiguity is necessary but not sufficient condition. In determining traffic zones is difficult that homogeneity and spatial contiguity exigencies can coincide. Choi and Kim (1995) individuated three fundamental methods with which you can face the BSUs' aggregation:

- a) The hierarchical heuristic approach;
- b) The statistical approach;
- c) The combined geographic information system (GIS) and statistical approach.

Cluster analysis techniques, to obtain the maximum homogeneity inside each zone, have instead

been classified by Lorr (1983). Among these, the most efficacious are the *agglomerative* one and the *iterative partitioning* one. Jinsoo You, Zorica Nedović-Budić e Tschangho John Kim (1996) have carried out a traffic zones design method, given the spatial aggregation level to achieve, which is an hybrid of the two. Both methods rely on measuring the similarity between BSUs. Euclidean distance and correlation coefficient are the most commonly used similarity measures.

To obtain different zonings, C. Ding adopts an agglomerative methodology. Euclidean distance is the similarity measure used as expressed in equation (2.1)

$$d_{ij} = [\sum_r w^r (X_i^r - X_j^r)^2]^{0,5}$$

in which with X^r are indicated the socioeconomic attributes of each BSUs while with w are indicated the weights associated to each attribute.

2.9 The Geographic Information System Layers

A general characteristic of Geographic Information Systems is their structure formed by layers overlapped. To each of these layers only a level of information is associated.

The first layer, on which all the others are based, holds socioeconomic information of the study area subdivided into census sections (1429 for the city of Bari accounting to the 1991 census). Their elaboration by aggregation procedures, allows to determine TAZs' socioeconomic characteristics, useful to specify systematic utilities associated to zones in demand models.

The attributes immediately available from ISTAT census data, are: employees in industrial sector, employees in the public services sector, employees in the private services sectors, resident population older than 14 years, resident families, workers in industrial sector, workers in the public services sector, workers in the private services sectors, workers in the trade sector, resident

population.

Other attributes can be associated: places in upper secondary schools, places in lower secondary schools, places in primary schools etc. Moreover, for each zoning the routines of GIS software allow to determine and to associate to elements some physical characteristics of census sections, as area or the geographic co-ordinates of zone's centroid. The second layer holds the cartography of study area, georeferenced, that allows to locate the physical separators (railways, rivers, etc) and the road network. On the third and the forth layer are represented respectively the graph of the network and the discretization of study area into traffic zones.

2.9.1 Zoning of Study Area

In the continuation, are explained the criteria adopted for the construction of a generic zoning and the procedure of clustering used to construct n zoning systems each one characterized by a number m of zones.

At the beginning a zoning characterized by an exiguous number of zones is considered through a procedure of aggregation of the BSUs based on the only criterion of physical separators. In subsequent phases, each zone is further subdivided into smaller zones. The criterion to adopt in aggregation of census sections, in these subsequent phases, must guarantee the construction of zones that show characteristics of homogeneity with respect to one of more attributes. The criterion of compactness is verified visually and with simplicity using GIS technology. With this object in view, a procedure of K-means cluster analysis is used. This technique, to evaluate dishomogeneity among zones with respect to attributes, uses euclidean distance:

$$d_{ij} = (\sum_k (X_i^k - X_j^k)^2)^{0,5}$$

The attributes X_i^k considered in this analysis are: number of employees, number of resident families, resident population, area of BSUs, geographic co-ordinates of the barycentre of the BSUs. The number of families is directly linked to the number of cars possessed while the geographic co-ordinates are indispensable to evaluate the contiguity among the census sections.

To each attribute X_i^k a weight β_i is associated, on the base of his relative importance, and a procedure of standardization is adopted to make sure that the results is not affected by the size of each attribute. Consequently the expression of distance will become:

$$d_{ij} = [\beta_1(Z_{1j}-Z_{1i})^2 + \beta_2(Z_{2j}-Z_{2i})^2 + \beta_3(Z_{3j}-Z_{3i})^2 + \beta_4(Z_{4j}-Z_{4i})^2 + \beta_v[(X_j-X_i)^2 + (Y_j-Y_i)^2]]^{0.5}$$

- Z_1 standardized variable of resident population ($\beta_1 = 0,15$)
- Z_2 standardized variable of employees ($\beta_2 = 0,15$)
- Z_3 standardized variable of number of families ($\beta_3 = 0,1$)
- Z_4 standardized variable of the area of BSU ($\beta_4 = 0,05$)
- X_j, Y_j standardized catographic co-ordinates of the barycentre of the area of the BSU ($\beta_v = 0,55$).

The weights β showed represent an hypothesis in which the criterion of contiguity is privileged. The results obtained in the application with the adoption of this values are coherent with the territorial reality used in application; a sensitivity analysis will can be developed to specify the value to attribute case by case.

The simulations, for the analysis of different alternatives of zoning, have been ten, characterized by a number of 10, 15, 20, 30, 40, 50, 60, 65, 70, 75 zones.

Two cases are shown in the figure 2.44 and 2.45.

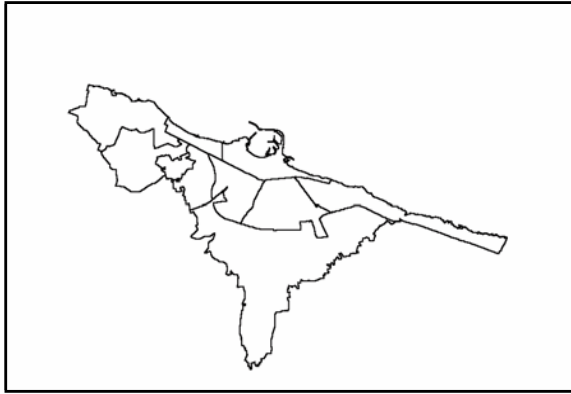


Figure 2.44 10 Traffic Analysis Zones

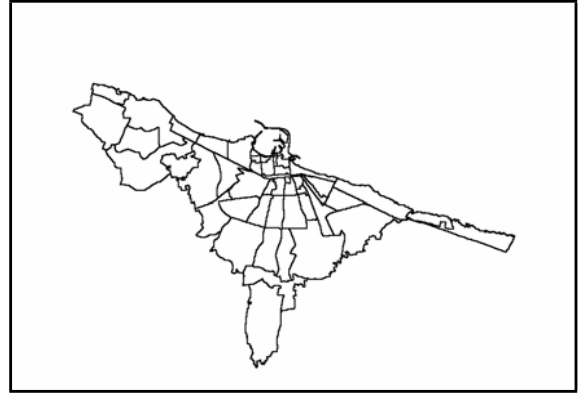


Figure 2.45 50 Traffic Analysis Zones

2.9.2 Modeling of Transportation Supply System

To analyze and to compare the ten hypothesis of zoning, it is necessary the construction of a supply model, which is considered constant by changing the level of discretization of territory and a demand vector $\mathbf{d}$ variable with the number of zones.

The supply system, relative to the road network, is modeled with a synchronic network (Cascetta, 1998).

The graph associated to the road network is constructed through a software GIS with the acquisition of the cartography normally available. This tool allows, with extreme facility, to select the transportation infrastructures which have an important role in connecting the traffic zones in the study area and external zones.

GIS technology allows, besides, associating to each element of the graph all the information useful to describe the network: identification codes, cost functions, prominent flows, etc.

With the hypothesis of congested network, the supply model is expressed formally by a relation that bind the link cost with path flows and the link flows with the path flows :

$$\mathbf{C} = \mathbf{A}^T \mathbf{c}(\mathbf{A}\mathbf{F}) + \mathbf{C}^{\text{NA}}$$

$$\mathbf{f} = \mathbf{A} \mathbf{F}$$

$$c_l = c_l(\mathbf{f})$$

In the application, non-additive costs $\mathbf{C}^{\text{NA}}$ have not been considered and as cost function has been adopted a separable one $c_l = c_l(f_l)$.

The graph associated to the road network of the city of Bari is represented with 677 nodes and 1475 network links. The internal centroids and the relative connectors are variable with the number of zones considered in each simulation. The centroids outside the study area, in number of 11 constant for each simulation of zoning, are located about road sections of access to the study area and linked to the network with connectors.

2.9.3 The Estimate of Transportation Demand and Assignment to the Network

The vector of demand $\mathbf{d}$, variable for each simulation, is estimated through a partial share model resulted from the application of four sub-models: emission model, distribution model, modal split model and path choice model:

$$d_{od}(s,m,k)=d_o \cdot (s,h)[\mathbf{SE},\mathbf{T}] \cdot p(d/osh) [\mathbf{SE},\mathbf{T}] \cdot p(m/odsh) [\mathbf{SE},\mathbf{T}] \cdot p(k/modsh) [\mathbf{SE},\mathbf{T}]$$
 For

the model of emission is utilized a descriptive model: $d_o \cdot (s) = \sum_C m_C(s) \cdot N_o(C)$.

For distribution and modal, feet and cars, split models are utilized *logit* models:

$$p(d/os) = \exp(\alpha V_d) / \sum_d' \exp(\alpha V_d')$$

$$p(m/ods) = \exp(\alpha V_m) / \sum_m \exp(\alpha V_m)$$

In both them the systematic utility V_d is valuable as a linear combination of attributes peculiar of the destination zone d or of the mode m , on the base of parameters γ_k :

$$V = \sum_k \gamma_k X_k$$

For the model of choice of the path, on the contrary, the *probit* model is utilized.

The result of the application of the four step model are so much vectors of demand as TAZ alternatives. Construted the supply model and the demand model, the phase of assignment, in hypothesis of rigid demand, is carried out. The approach followed for the assignment is the User.

Equilibrium one, for congested network, with a SUE model

$$f^* = f_{SNL} \quad f \quad (c(f^*); d)$$

and a resolutive algorithm MSA-FA.

2.9.4 Comparison and Evaluation of Numeric Results.

For each TAZ alternatives produced the traffic flows on each link of the network have been estimated and network performance indicators as the total cost ($TC = C^T F$), the average cost ($AC = C^T F / 1^T F$), the congestion index PCP ($I_C = \sum_l [(G_s l \cdot f_l) / \sum f_l]$), the number of saturated links ($G_s > 80\%$).

The results obtained for these indicators are represented in figures 2.46, 2.47, 2.48

and 2.49 are indicated in the Table 2.3.

Table 2.3 Network performance indicators

n. zones	10	15	20	30	40	50	60	65	70	75
Total cost (hour)	75127	86750	18197	17847	15196	16907	16278	13898	14183	13348
Average cost (sec)	3734	4749	936	928	805	901	838	715	715	696
Average cost with C=0	940	772	616	569	588	614	622	501	492	492
Number of saturated links	341	200	140	158	89	99	86	86	99	101
Indicator of congestion PCP	88.74	83.23	53.91	56.73	48.25	50.81	48.39	47.88	48.45	47.79

The analysis shows a threshold of number of zones beyond which the values of network performance indicators present a stability of results included in a range of $\pm 20\%$ around the mean between the maximum and the minimum of results obtained in the simulations. This variability of results is coherent with the stochasticity of the model of assignment used (parameter of the variance of the costs of the *Probit* model equal to $\vartheta = 10$ s, n. SNL iterations= 50) and of the stop test of the algorithm MSA (M.G. Binetti, 1996).

For the city of Bari the threshold is individualized in 20 zones.

The results, moreover, shows coherence with other analysis effected in the case of extra-urban networks with estimation of demand effected with a gravitational model (Ding, 1998).

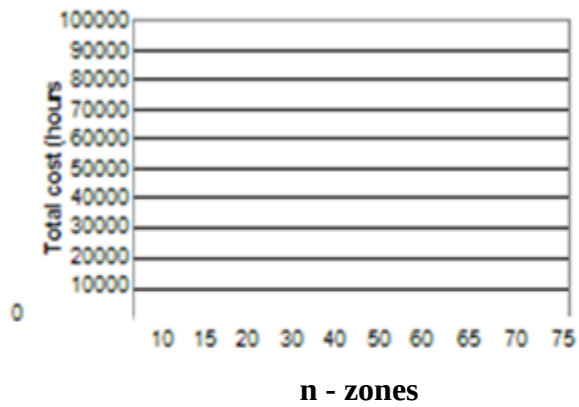


Figure 2.46 Total cost on the network

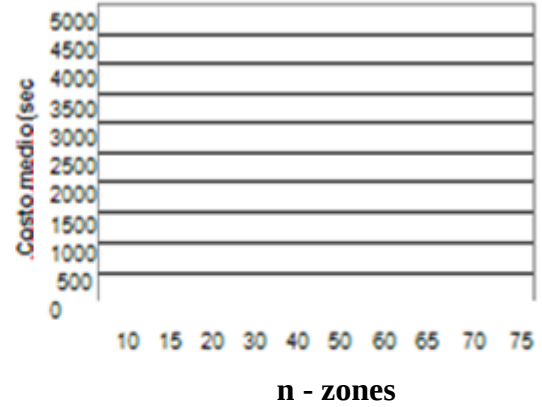


Figure 2.47 Average cost on the network

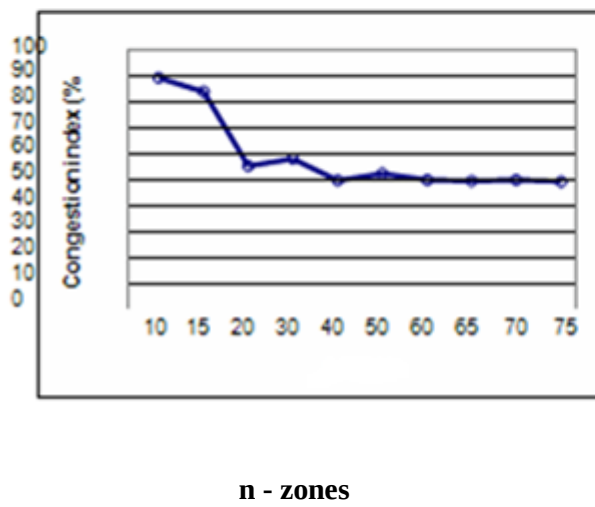


Figure 2.48 Congestion index PCP

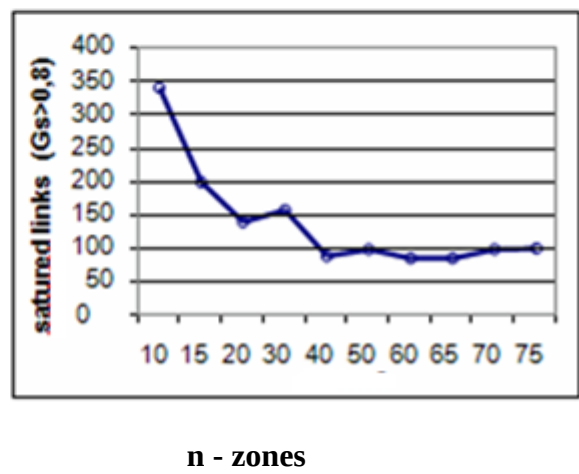


Figure 2.49 Number of saturated links

2.9.5 2000 Transportation Analysis Zone Structure

Worthy of notice is the document the new 2000 transportation analysis zone (TAZ) structure which the Baltimore Metropolitan Council (BMC) developed in cooperation with its member jurisdictions (Baltimore City and Anne Arundel, Baltimore, Carroll, Harford, and Howard counties) and the Maryland Department of Transportation (MDOT). The development of the 2000 TAZ structure is one of several tasks the BMC has recently completed to enhance the Baltimore region travel demand model. The BMC maintains this model and uses it to generate traffic, transit, and air quality conformity forecasts as part of the transportation planning process.

The 2000 TAZ structure was developed from the 1998 TAZ structure using 2000 Census Geography as part of the Census Bureau's TAZ-Up Program. Transportation Analysis Zone Structure documents the 1998 TAZ structure. Most TAZs were defined as block groups or combinations of block groups. In Anne Arundel and Baltimore counties and Baltimore City; however, some TAZs remained or were specified below the block group level as collections of census blocks. No TAZs split census blocks. TAZs generally nest within the BMC's Regional Planning District geography; however, there are exceptions to this rule where TAZs split block groups.

The new TAZ structure was developed to improve the accuracy of the Baltimore region travel demand model's forecasts and to create a smaller zone structure for use in corridor and local planning analysis. The smaller TAZ structure minimizes intra-zonal trips, which are by nature excluded from zonal modeling and, therefore, better estimates traffic volume, VMT, and air quality emissions. Table 2-4 shows the number of TAZs by jurisdiction in the 1998 versus the 2000 TAZ structure. The number of TAZs in the Baltimore region increased

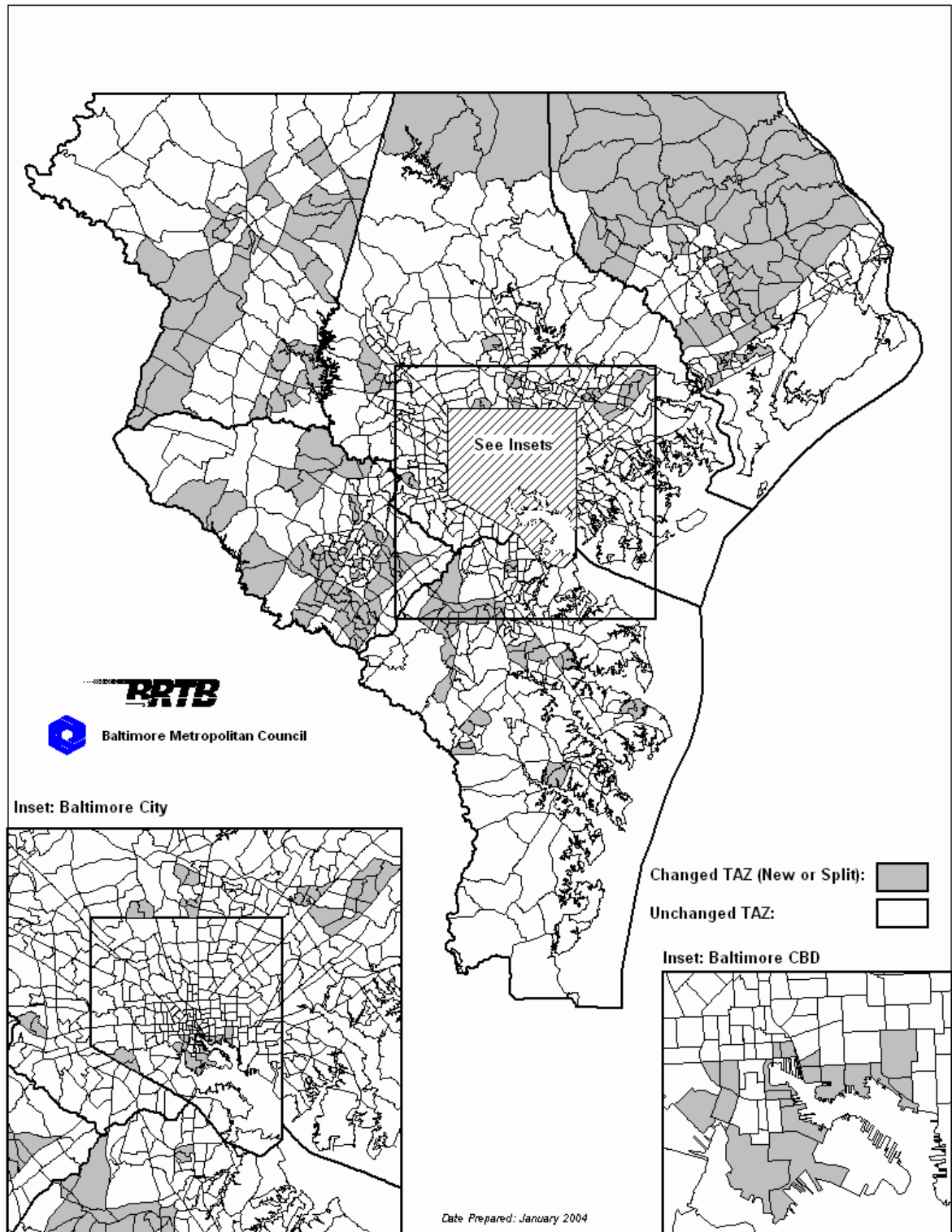
from 1,014 to 1,151

A map showing the 2000 TAZ structure for the Baltimore Region Travel Demand Model is shown in Exhibit I. TAZs that were changed from the 1998 TAZ structure are shown in gray while TAZs that were not changed are white. Most of the 137 new TAZs that were added as part of the development of the 2000 TAZ structure are in outlying suburban areas well outside of the Baltimore Beltway (I-695). A total of 124 were located outside of the beltway compared to only 13 within the beltway. Of the TAZs added within the beltway, most were in the Inner Harbor or Towson areas. The Inner Harbor had nine TAZs added and Towson had three.

Table 2.4 : 1998 vs. 2000 TAZ Structure by Jurisdiction

Jurisdiction	1998 TAZs	2000 TAZs	Number of TAZs Added	1998 TAZ Numbering	2000 TAZ Numbering
Baltimore	207	217	+10	1 to 207	1 to 217
Anne Arundel Co.	193	208	+15	208 to 400	218 to 425
Baltimore Co.	325	342	+17	401 to 725	426 to 767
Carroll Co.	76	95	+19	726 to 801	768 to 862
Harford Co.	100	140	+40	802 to 901	863 to 1,002
Howard Co.	113	149	+36	902 to 1,014	1,003 to 1,151
Baltimore Region	1,014	1,151	+137	1 to 1,014	1 to 1,151

Baltimore Region Transportation Analysis Zone Structure



Transportation Analysis Zone Maps by Jurisdiction

Exhibit I

CHAPTER THREE

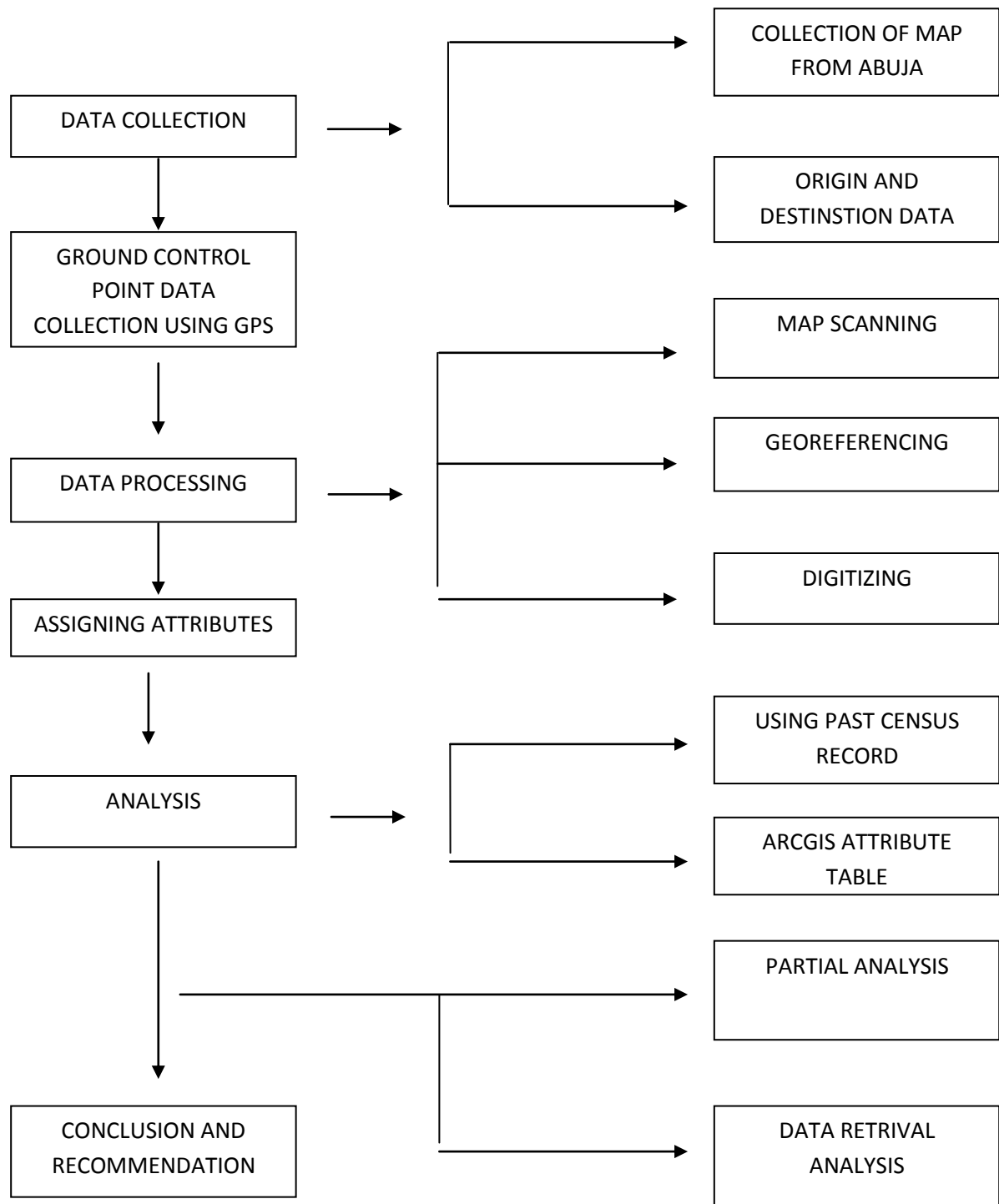
MATERIALS AND METHODS

Following the digitization of the road map of the study area and obtaining transport characteristics such as vehicle types, road sizes and so on, the following processes will be used for the research work.

3.1 BACKGROUND

GIS is a technique for managing and processing location and related information. It visually displays the results of analyses, thus enabling sophisticated analysis and quick decision making. Recently, systems using GIS have been developed for use in various disciplines. Development of a system that uses GIS to analyze traffic analysis zone has been pursued toward improving the efficiency and effectiveness. Establishment of the system requires a design that enables constructed databases to be used efficiently by GIS. Toward developing a flexible system that achieves this goal, ArcGIS 9.3 is used, a GIS software application from ESRI (Environmental System Research institute). The following flow chart shows the methodology of the work.

3.2 FLOW CHART:



3.3 GROUND CONTROL POINT (G.C.P)

Ground control point was collected for 11 different coordinate locations from my study area.

The data collected is shown in table 3.1

Ground Control Point Table

Table 3.1: Showing Ground Control Points.

NORTHING	EASTING
336720.151995	1005351.27178
333777.779322	1000628.68590
333043.461012	1000179.93582
332798.688242	1005488.44527
331436.404259	1003355.07993
330328.057087	1002550.33871
335379.206052	999807.149006
333636.977008	1001742.80468
335399.398924	1001653.67187
335267.456822	1001859.83141

334323.158545	1002446.67866
---------------	---------------

Source: From Abuja Federal Capital City (F.C.C)

3.4 LOCATION OF STUDY AREA

The study area is Federal Capital Territory Abuja located along longitude 7° E and latitude 9° N on the map of Nigeria.

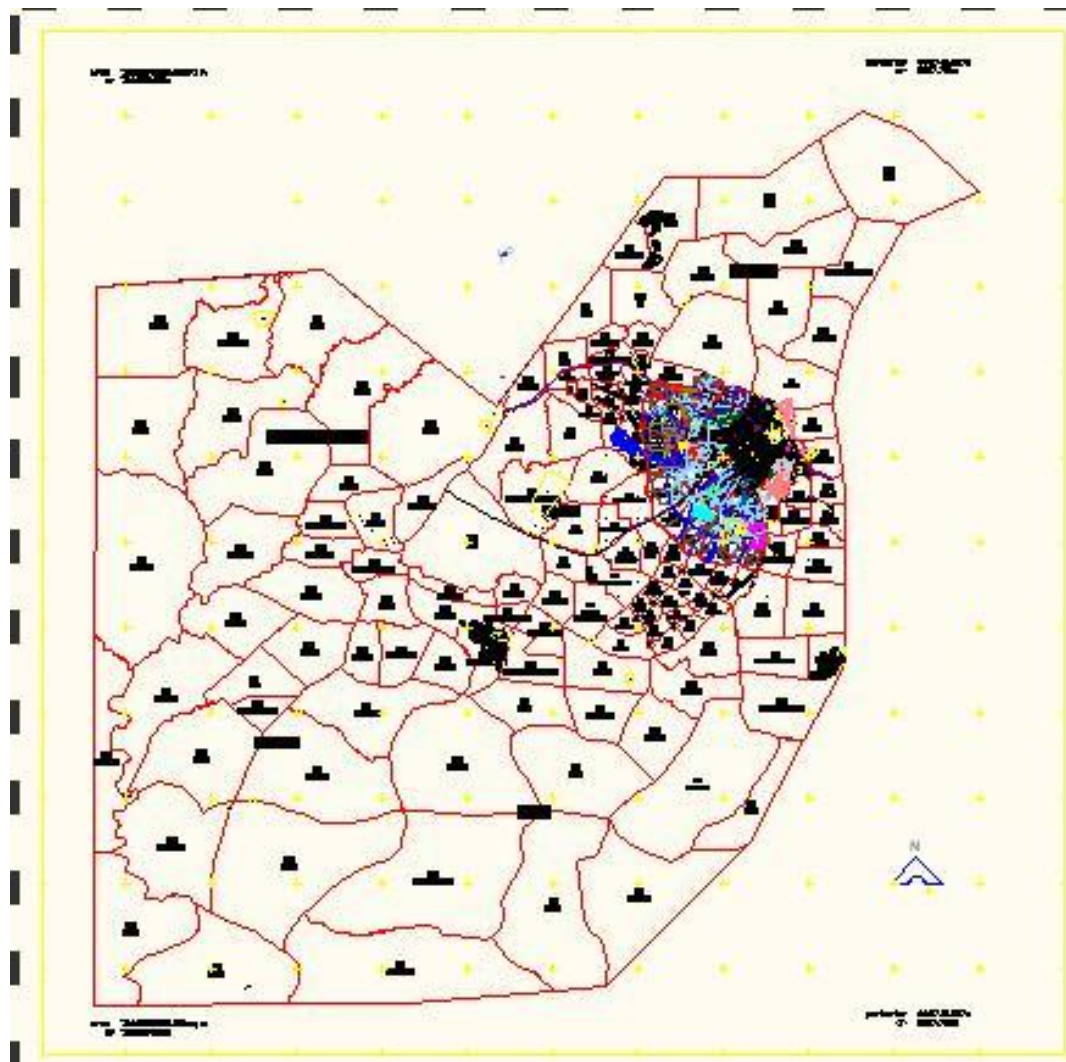


Fig 3.1: Showing Map of Federal Capital Territory

3.5 GIS LAYERS

A GIS map is made up of *layers*, or collections of geographic objects that are alike. In order to make a map we can add as many layers as we want.

3.5.1 Layers Features

The road layers spans a number of traffic analysis zones and the districts covers so many other zones. Each geographic object in a layer is called a *feature*.

3.5.2 Features Have Shape and Size

Geographic objects have an endless variety of shapes. All of them, however, can be represented as one of three geometrical forms-a polygon, a line, or a point. Polygons represent things large enough to have boundaries, such as countries, counties, lakes and tracts of land. Lines represent things too narrow to be polygons, such as rivers, roads, and pipelines. In our case we use road polygons instead of road lines. Points are used for things too small to be polygons, such as crash locations, cities, schools, and fire hydrants. (The same object may be represented by a polygon in one layer and a line or a point in a different layer, depending on how large it is presented). Polygons, lines, and points collectively are called vector data.

3.5.3 Features Have Locations

GIS uses a fine grid that is called a coordinate system to put features in their proper places on a map. The location of a point feature on a map is defined by a pair of x, y coordinates. A straight line needs two pairs of coordinates-one at the beginning and one at the end. If the line bends,

there must be a pair of coordinates at every location where the line changes direction. The same is true for a polygon, which is simply a line that returns to its starting point.

3.5.4 Features Have Zooming Tendencies

On a GIS map, we can zoom in to see features at closer range. As we do so, the scale of the map changes. Scale, commonly expressed as ratio, is the relationship between the size of features on a map and the size of the corresponding places in the world. If the scale of a map is 1:100,000,000, it means that features on the map are one hundred million times smaller than their true size. Zooming in provides with a closer view of features within a smaller area. The amount of detail in the features does not change, however. The number of detail features that a map has depends on the used layer. GIS layers can contain more future detail or less.

3.5.5 Features are Linked to Information

There is more to a feature than its shape and location. There is everything else that might happen to be known about it. For a crash, this might include the number of vehicles involved, major factor contributing to the crash, number of injuries and fatalities, etc. for a road, it might be its speed limit, the number of lanes it has, pavement description, and whether it is one-way or two-way. Information about the features in a layer is stored in a table. The table has a *record* (row) for each feature in the layer and a *field* (column) for each category of information. These categories are called *attributes* (Figure 3.1)

OID	MONTH	TAR	VIFA	VISA	VIMA	DAM	DAF	DCM	DCF	IAM	IAF	ICM	ICF	ID*
0	JAN	25	2	9	14	2	-	-	-	6	2	1	-	1
1	FEB	30	5	11	14	3	1	1	-	6	4	-	1	2
2	MAR	23	2	5	15	2	-	-	-	3	2	-	-	3
3	APR	10	-	4	6	-	-	-	-	3	2	4	1	4
4	MAY	8	-	3	5	-	-	-	-	3	2	4	1	5
5	JUN	11	3	-	8	1	1	-	-	3	2	-	-	6
6	JUL	15	4	-	11	2	1	-	-	4	2	-	-	7
7	AUG	22	3	11	8	3	2	1	-	5	2	2	1	8
8	SEP	21	4	-	17	1	1	-	-	3	4	-	-	9
9	OCT	16	8	3	5	2	-	1	1	2	5	-	-	10
10	NOV	30	15	3	12	8	3	2	-	2	1	-	-	11
11	DEC	36	6	10	15	2	1	2	-	4	2	5	3	12
12	TOTAL	247	52	59	130	26	10	7	1	44	30	16	7	13

Figure 3.2: Screenshot of Attribute Table.

Features on a GIS map are linked to the information in their attribute table. If we highlight a specific TAZ on the map, we will be able to bring up all the information stored about it in the attribute table for TAZ. If we highlight a record in the table, we will see the corresponding feature on the map. The link between features and their attributes makes it possible to ask questions and create queries about the information in an attribute table and display the answer on the map (Figure 3.2)

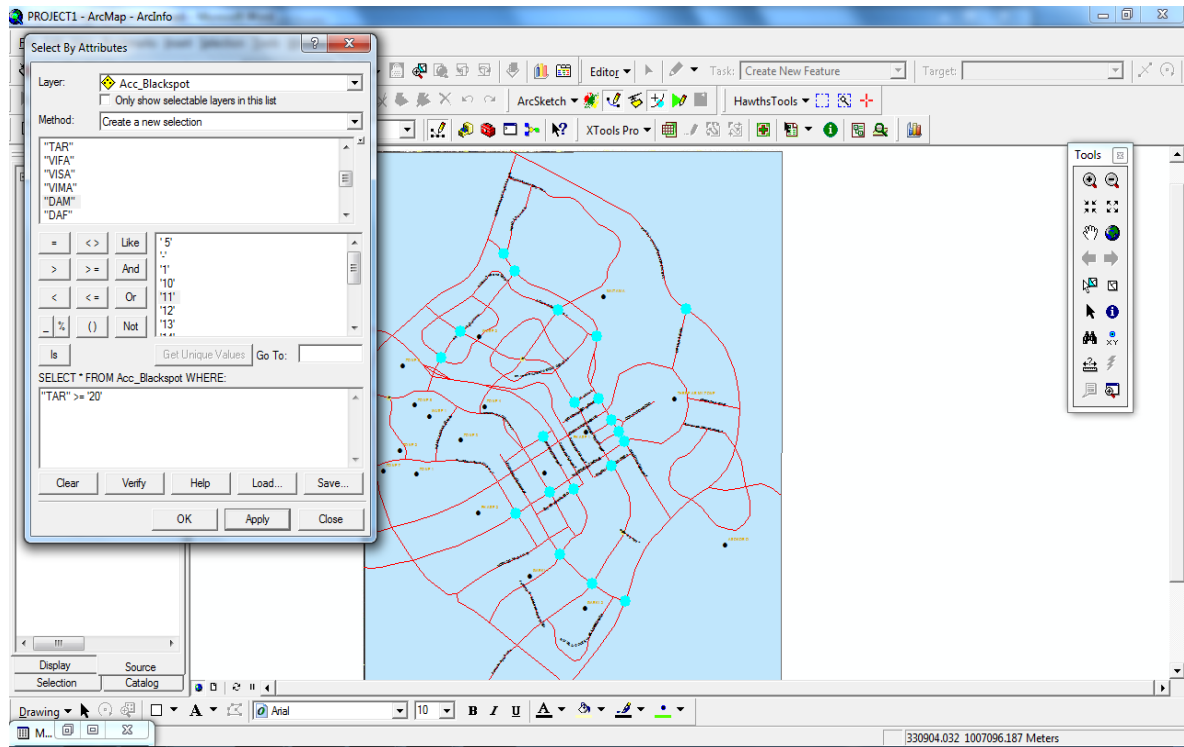
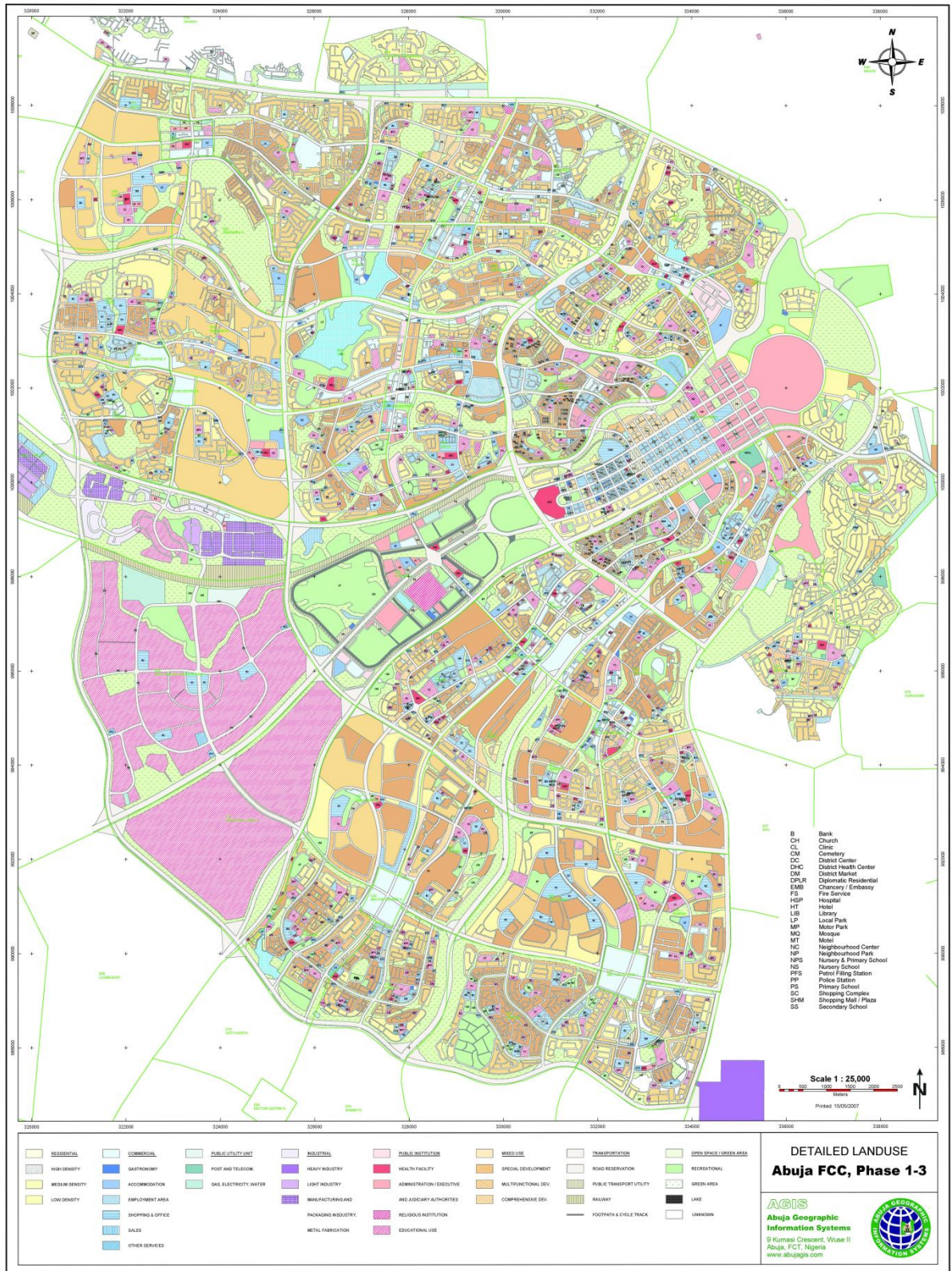


Figure 3.3: Screenshot of Query of TAZ.

Similarly, we can use attributes to create thematic maps, maps in which colors or other symbols are applied to features to indicate their attributes. A typical thematic map is shown at Fig 3.3 below.



3.5.6 Features Have Spatial Relationships

Besides asking questions about the information in attribute tables, we can also ask questions about the spatial relationships among features—for example, which ones are closer to others, which ones cross others, and which ones contain others. The GIS uses the coordinates of features to compare their locations.

3.5.7 The ArcMap, ArcCatalog, and ArcToolbox Applications

In ArcMap we are able to create maps from different layers of spatial data, choose colors and symbols, query attributes, analyze spatial relationships, and design map layouts. The ArcMap interface contains a list (or table of contents) of the layers in the map, a display area for viewing the map, and menus and tools for working with the map (Figure 3.3)

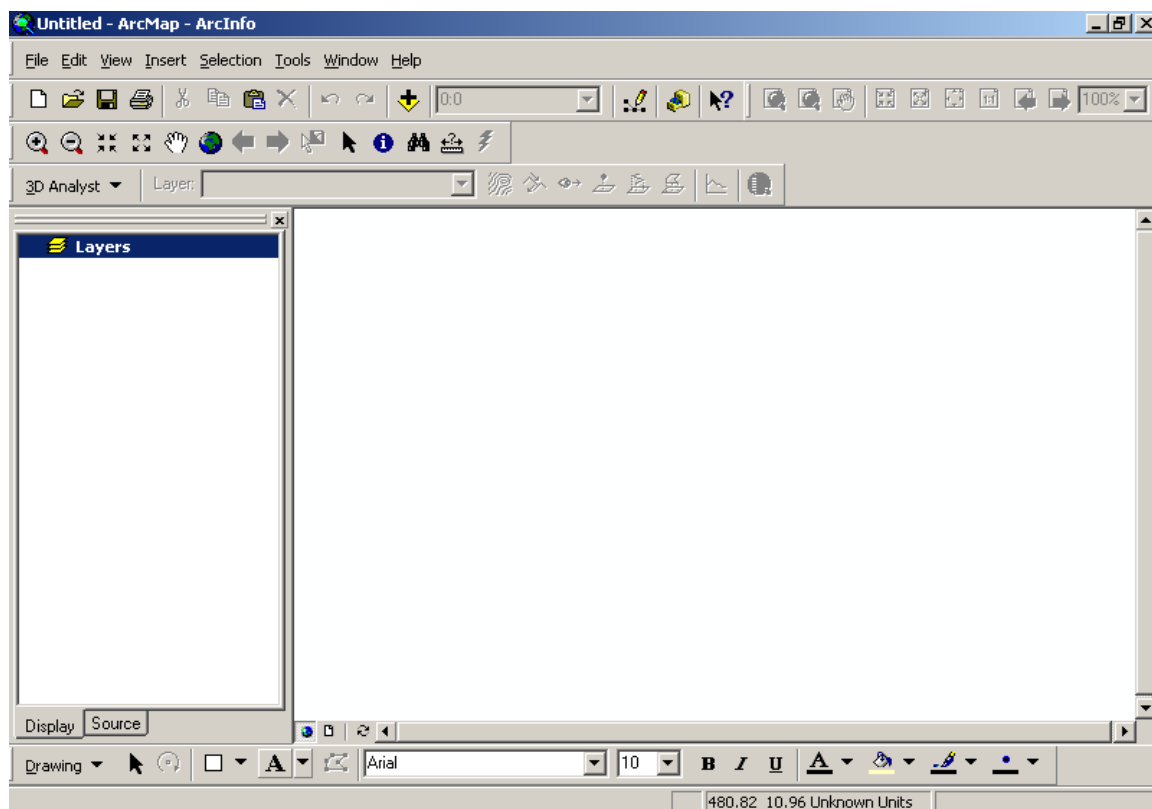


Figure 3.4: Screenshot of ArcMap Window in ArcGIS Desktop.

ArcCatalog is an application for managing geographic data. In ArcCatalog, we browse spatial data contained on our computer's hard disk, on a network, or on the Internet. We can search for spatial data, preview it, and add it to Arc Map. Arc Catalog also includes tools for creating and viewing metadata, which is the information regarding the spatial data, such as who created it and when, its intended use, its accuracy, and so forth. A folder can contain shape files, which is a vector data storage format for storing the location, shape, and attributes of geographic features. A shape file is stored in a set of related files and contains one feature class. Geographic features in a shape file can be represented by points, lines, or polygons (areas). The folder might also contain the BASE tables, which can store additional attributes that can be joined to a shape file's features (Fig 3.4).

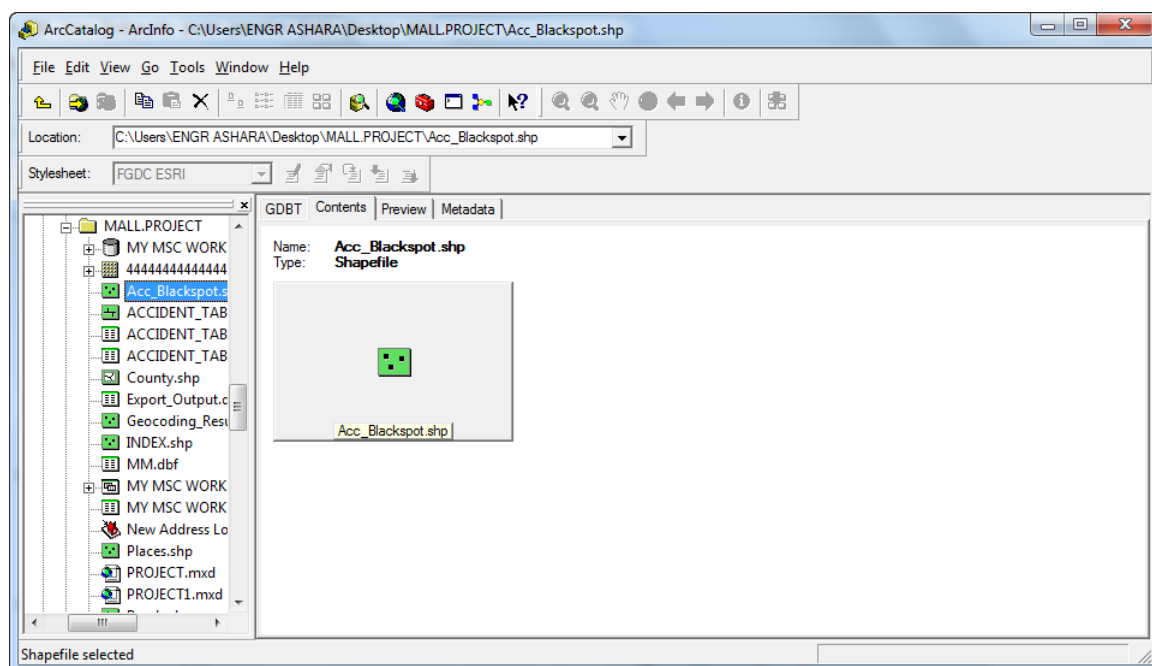


Figure 3.5: Screenshot of Arc Catalog Window.

In Arc Toolbox, we can use tools to convert spatial data from one format to another and to change the map projection of data (Fig 3.5)

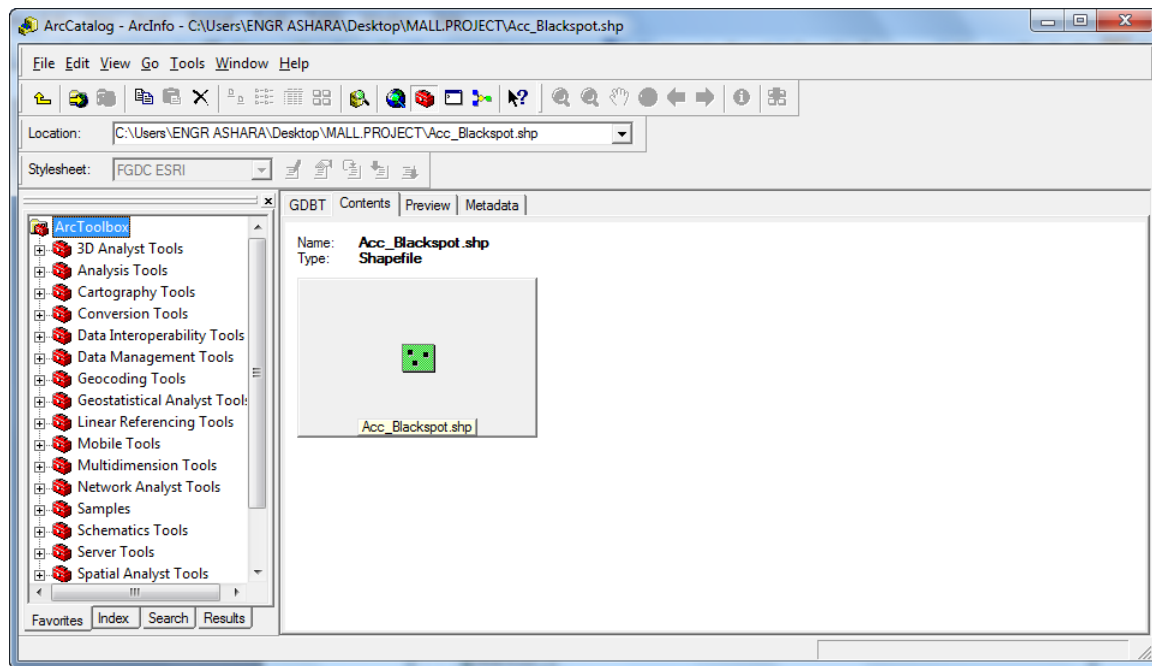


Figure 3.6: Screenshot of Arc Toolbox Window.

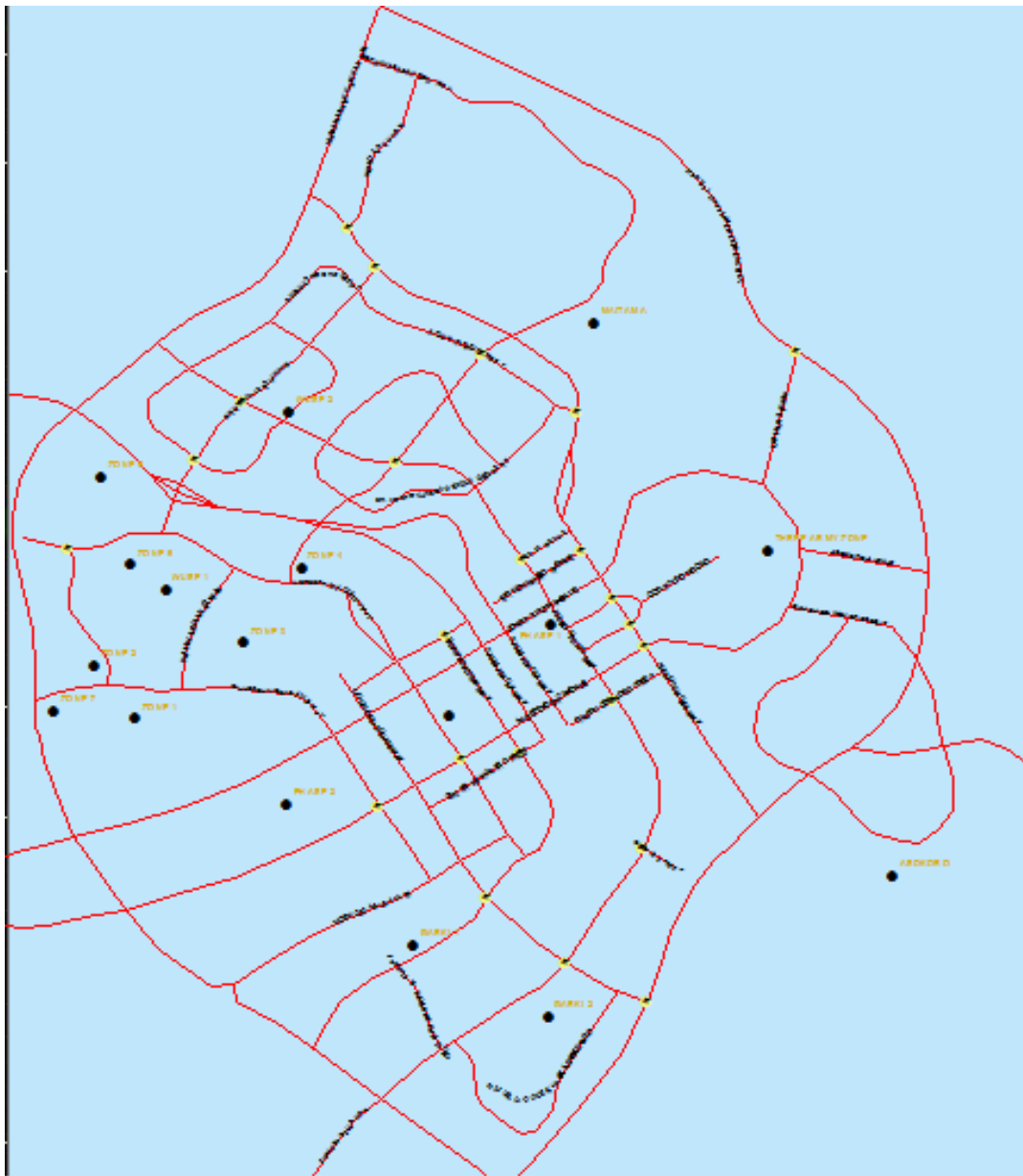


Figure 3.7: Screenshot of Map of Abuja Using ArcGis Desktop.

3.6 Criteria

The following criteria were considered as part of the adopted methodology of zoning.

3.6.1 Physical Geography of Study Area

Physical Geography is a basic requirement for delineating traffic analysis zone. The map of Abuja provided the major input as the requirement of physical geography. Using the Census Enumeration Area Data (CEAD) map obtained from the National Population Commission (NPC) Abuja, CEAD as classified by INEC and documented by NPC is an area containing about 1000 persons. The areas are distinctively marked out on the map of the study area and were used for the citing of polling zones. The markings of those areas make them suitable as a basis for delineating the traffic zones combining it with other criteria. Fig 3.7 shows an example of a marked district with the CEAD.

3.6.2 Adopted Zoning Structure

There are three zoning structure, these includes large, medium, and small size zoning structure. The small zoning size has many advantage over other zoning structure. The advantages includes the following:

- a. Rooms for more details.
- b. Smaller number of people in a zone.
- c. Better accuracy in zoning.

Three CEAD were combined to form a TAZ unit. Three TAZ were combined to arrive at a district for analysis of the desire line. Fig 3.7 shows the samples of the CEAD maps that was

used to build the TAZ units while fig 3.8 contains the districts comprised of the TAZs respectively.

of FCC using GIS

3.6.3 Methodology of O-D Matrix Generation

For the production of the graphic and digital desire line, it is necessary to form an O-D matrix showing the various trips generated from different origins to the desired destinations. An O-D survey was conducted using then questionnaire at Fig 3.9. The adopted approach was to conduct home interview of people who usually go out for business and other activities and road side interview at selected parks. The methodology for the survey and administration of questionnaires is diagrammatically depicted in fig 3.10. The resulting O-D matrix table is at Fig 4.1. only inter-zonal trips were considered intra-zonal trips could be another subject of discuss in future research.

ORIGIN- DESTINATION SURVEY QUESTIONNAIRE

Questions:

1. This trip began at (check one only)
make this trip? (check one

☐ Home ☐ Friends or Relative home only

☐ My workplace ☐ Personal Appointment ☐ Less than once a week

☐ School ☐ Business Appointment ☐ One of the five times a week

☐ Shopping/Errands ☐ Restaurant ☐ More than five times a week

☐ Other (Specify)

5. How often do you typically

6. On this particular trip, how many people

were in your vehicle including driver and all
the passengers

.....
.....

2. The place where this trip began:

.....

City/Town: -----

Street Address OR Nearest Intersection

7. If you made a stop on this

trip, what was the purpose of this stop? (Check all that apply)

Name of Business (if appropriate): ☐ Work place ☐ ☐
School ☐ Day care ☐

-----☐----- Gas ☐ auto service ☐

Eat Meal ☐ Recreation ☐

3. This trip ended at: (Check one only) ☐ Shopping ☐ Rest B ☐ ak
Errands

☐ Home ☐ Friends or Relative home ☐ Pick up or drop off passenger

☐ My workplace ☐ Personal Appointment ☐ Other (Specify)

☐ School ☐ Business Appointment -----

☐ Shopping/Errand ☐ Restaurant -----

☐ Other (Specify) If you would care to make any specify
suggestions

4. The place where this trip Ended: about how to improve travel
along your route,

City/Town: ----- please write them below
in the space provided.

Street Address OR Nearest Intersection -----

Name of Business (if appropriate): -----

Thank you very much for your Interest and cooperation!

☐	Please check here if no one at your address made the trip described in the cover letter
--------------------------	---

Figure 3.10 Destination Survey Questionnaire

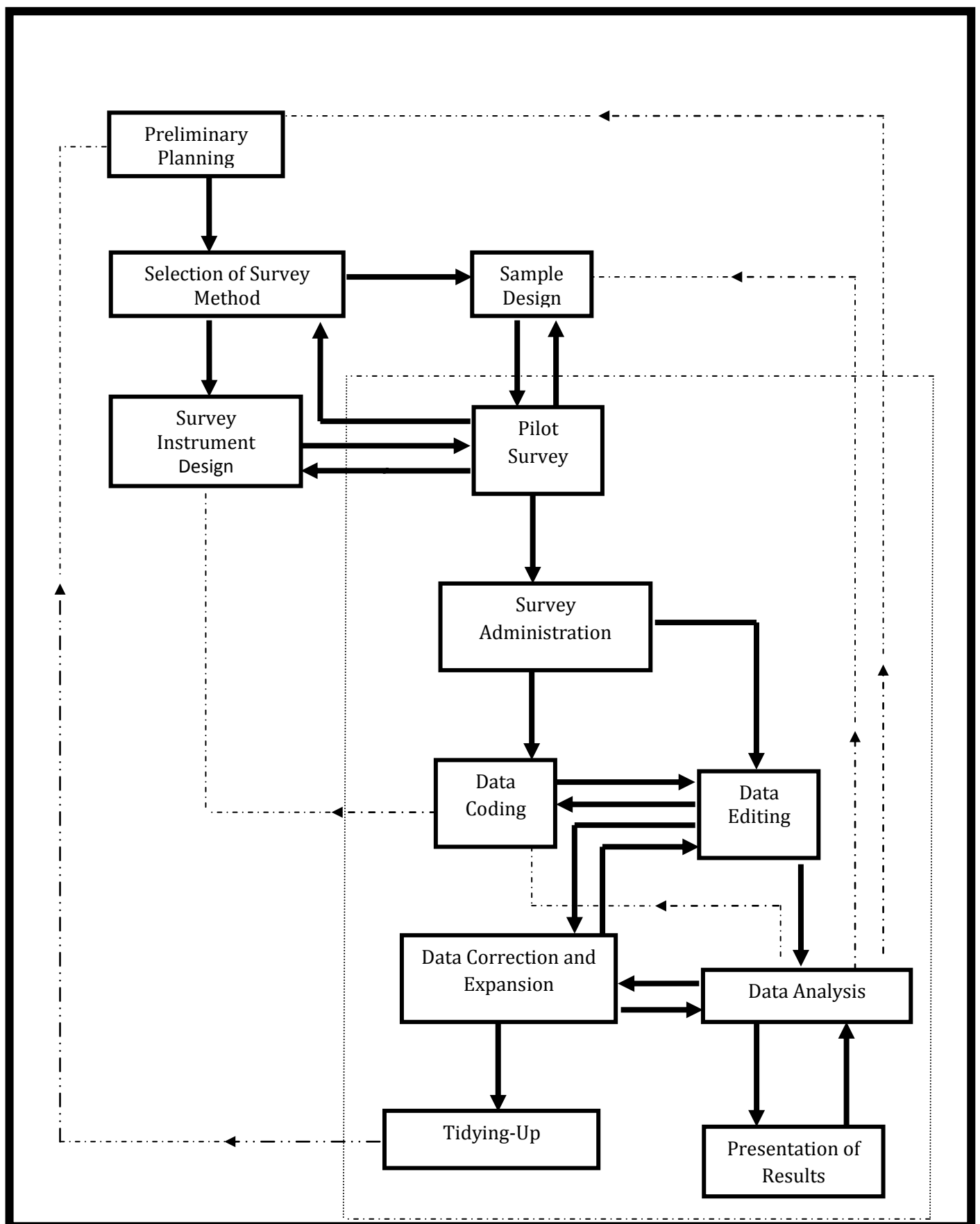


Figure 3.11 The Transport Survey Process

CHAPTER FOUR

4.0 APPLICATION OF THE PROGRAM AND DISCUSSION OF RESULTS

4.1 Data Description

The data set used in this analysis was collected from Abuja (F.C.T) through Home Interview Survey.

4.2 Analysis of the Data Collected

4.2.1 Attribute Table shows O-D Matrix Data

Attributes of DATA for O-D MATRIX

OID	ZONES_ALL	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11	F12	F13	F14	F15	F16	F17	F18	F19	F20	F21	F22	F23	F24	F25	F26	F27	F28	F29	F30	F31	F32	
0	1	567	45	345	23	58	79	45	346	98	243	325	34	23	5	10	23	2	65	9	68	0	0	0	0	0	0	0	0	0	0	0	0	0
1	2	97	8	0	0	0	0	0	45	78	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
2	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
3	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
4	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
5	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	0	0	0	0	0	
6	7	0	0	0	0	0	0	5	0	23	0	1	0	0	0	0	0	0	0	0	65	0	0	0	0	0	0	0	0	6	0	0	0	0
7	8	0	8	0	33	0	0	0	0	0	0	0	0	0	0	0	0	76	0	0	0	0	0	0	0	0	0	0	0	0	4	44	0	
8	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	67	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
9	10	0	0	0	0	0	0	5	0	0	0	0	0	88	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8	0	0	0	0	
10	11	0	0	4	0	0	0	0	8	0	6	0	0	0	0	0	0	0	0	0	0	58	0	0	0	0	0	0	0	0	235	0	0	0
11	12	0	0	0	0	0	0	0	44	0	0	0	0	0	0	0	0	44	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
12	13	0	4	0	0	0	0	9	0	0	0	0	67	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
13	14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	45	0	0	0	0	0	0	0	65	0	0	0	6	0	0	0	0	55	
14	15	0	0	0	0	45	0	0	0	0	0	0	0	0	0	0	0	0	0	46	0	0	0	0	0	0	0	0	0	44	0	0	0	
15	16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	78	0	0	0	0	
16	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
17	18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	65	0	0	0	0	0	0	0	0	0	8	0	0
18	19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
19	20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
20	21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
21	22	0	0	0	0	0	0	0	0	6	0	0	0	0	0	0	0	0	0	0	0	45	0	0	0	0	0	0	0	0	0	0	0	0
22	23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	
23	24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	65	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
24	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Record: 1

Show: All Selected

Records (0 out of 150 Selected)

Options

Figure: 4.1: Screen shot of O-D Matrix Data in ArcGis

Source: ABUJA

FID	Shape	Id	District *	Acreage	New_area
1	Polygon	2	ASOKORO	2694.36	10903693.81
2	Polygon	3	GARKI I	1223.21	4950148.08
3	Polygon	4	GARKI II	1159.43	4692064.87
4	Polygon	5	WUSE	1615.51	6537751.43
5	Polygon	6	WUSE II A	751.75	3042238.77
6	Polygon	7	MAITAMA I	1595.97	6458656
7	Polygon	8	GUDU	1528.86	6187068.75
8	Polygon	9	DURUMI	1253.07	5070995.24
9	Polygon	10	KUKWABA	3243.98	13127928.92
10	Polygon	11	WUYI	1232.91	4989399.07
11	Polygon	12	UTAKO	1172.2	4743722.23
12	Polygon	13	MABUSHI	1344	5438959.89
13	Polygon	14	KATAMPE	1887.77	7639555.55
14	Polygon	15	JAHI	1285.59	5202622.61
15	Polygon	16	KADO	1618.07	6548116.71
16	Polygon	17	JABI	1140.53	4615572.94
17	Polygon	18	DAKIBIYU	1804.47	7302432.3
18	Polygon	19	DUBOYI	881.57	3567587.66
19	Polygon	20	KAURA	1432.38	5796653.1
20	Polygon	21	GADUWA	1502.99	6082381.33
21	Polygon	22	DUTSE	2012.36	8169013.36

Figure: 4.2 Screenshot of District Attribute Data in ArcGIS

Source: ABUJA

OID	ID	AREA	ID1	ZONES
134	150	2.53	0	zone1
142	1	5.11	0	zone1
122	10	0.67	0	zone10
40	100	10.01	0	zone100
41	101	9.6	0	zone101
56	102	5.18	0	zone102
43	103	4.79	0	zone103
57	104	3.83	0	zone104
58	105	3.26	0	zone105
44	106	1.61	0	zone106
45	107	2.47	0	zone107
46	108	3.98	0	zone108
47	109	5.34	0	zone109
8	11	0.72	0	zone11
76	110	3	0	zone110
77	111	1.57	0	zone111
78	112	2.01	0	zone112
79	113	2.81	0	zone113
80	114	1.73	0	zone114
81	115	0.99	0	zone115
116	116	1.09	0	zone116

Figure: 4.3 Screenshot of Zone Attribute Data in ArcGIS

4.2.2 QUERYING DATA IN ARCMAP

IDENTIFYING, SELECTING, AND FINDING FEATURES:

There are many ways to retrieve information about features in ArcMap™. The user can identify features by clicking on them in order to display their attributes. The user can select features by clicking on the features to highlight them and look at their records in the layer attribute table. The user can find features by using known information about the feature in order to search the map for that particular feature.

Identifying Features:

Perhaps the fastest way to get information about a single feature is to identify it, using the Identify Tool.

To use the Identify tool, the user must select it from the Tools Toolbar. Within the map, the user must click on the feature of interest in order to view the attribute information for that particular feature.

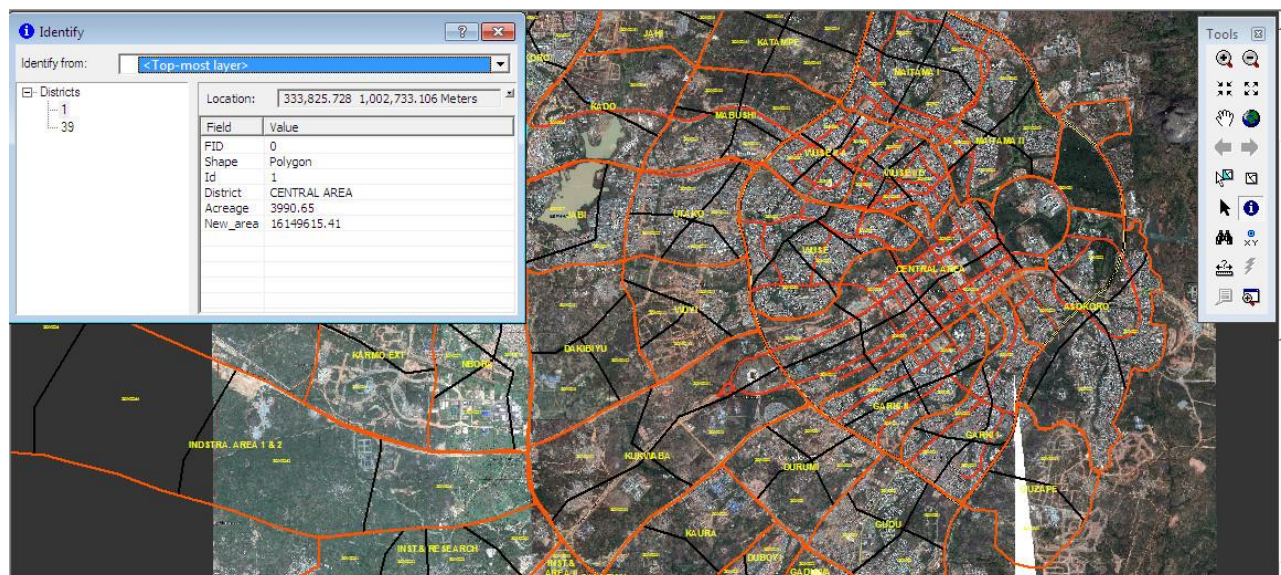


Figure 4.4: Screenshot of Map of Abuja Show Identify

Selecting Features:

If the user wants to compare information about several features, the best way is to select the features on the map and look at their records in the layer attribute table. The easiest way to select multiple features is by using the Select Features Tool on the Tools Toolbar.

To view the selected features' attribute table, the user must right-click on the data layer where features have been selected. The Open Attribute Table option should then be clicked.

Figure 4.5: Screenshot of Map of Abuja Showing “Select Features”

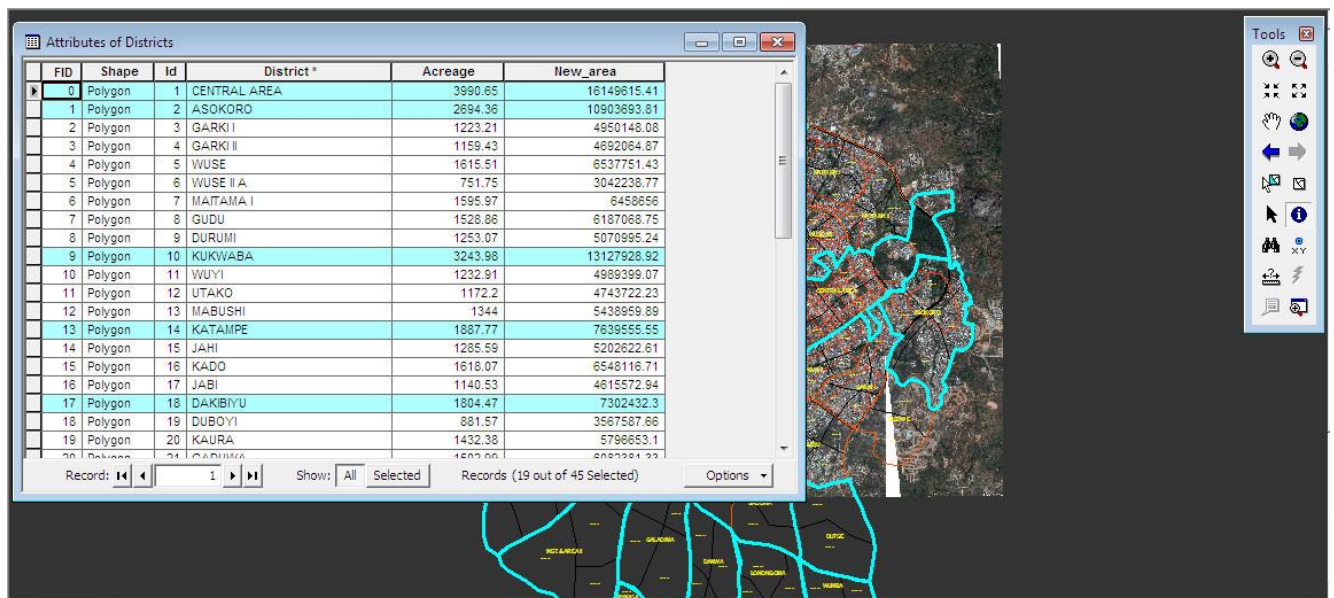


Figure 4.6: Screenshot of Map of Abuja Showing “Selected Features”

The user can group all of the selected attributes, by clicking on the selected button at the bottom of the attribute table. Only those features that were highlighted will appear.

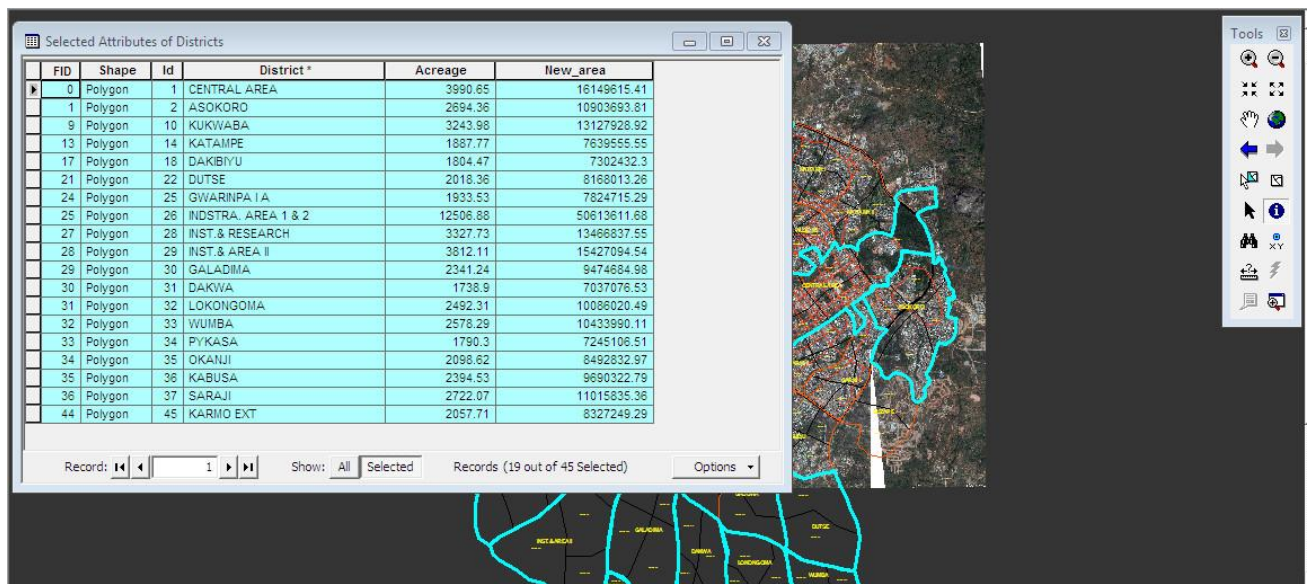


Figure 4.7: Screenshot of Map of Abuja Showing “Group Selected Features”

Now the user can easily compare various attribute values, such as Area.

Finding Features:

When the user has a piece of information about a feature, but is not sure where that feature is on the map, the user can search the map for that feature using the known piece of information.

The user can find a feature, by selecting the Find tool on the Tools toolbar. When the Find dialog Box appears, the Features tab should be selected. The known attribute information should be typed in the Find box. In the In Layers drop down box, the layer that the user wishes to find features in should be selected. In the Search options, the user should choose to either search all fields in the attribute table or a specific field. Once all parameters are set, the Find button should be clicked.

In the following example, the place of Wuse was found in the Abuja, Place Data Layer by typing in the known attribute information (i.e. place = Wuse, Wuse IIA and Wuse IIB).

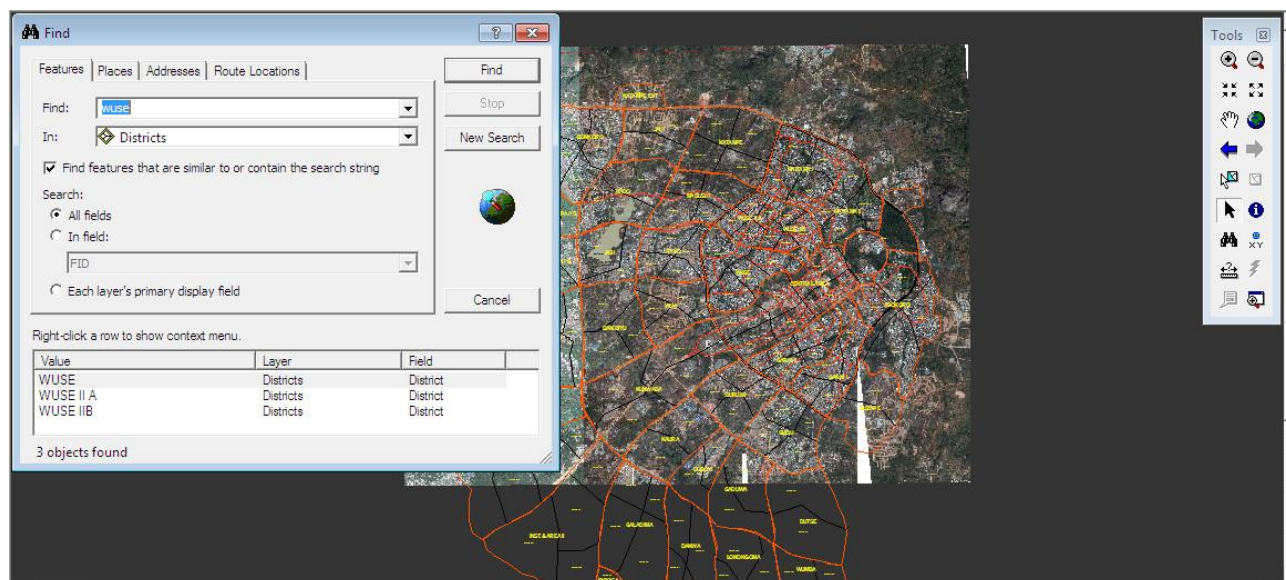


Figure 4.8: Screenshot of Map of Abuja Showing “Finding Features”

Once the Find button is clicked and the feature is found, the user can locate it on the map and get its attributes. This can be done when the user right clicks on the feature row found in the Find dialog box and clicks Identify Feature(s). The feature will briefly flash within the map display and the Identify Results dialog box will open.

4.2.3 Selecting Features by Attributes

In addition to identifying, selecting, and finding features, the user can select features by attributes by writing a query that automatically selects features that meet specified criteria. The simplest type of query consists of an attribute (such as PLACE), a value (such as 'Asokoro'), and a relationship between the two (such as 'equal to'). A more complex query combines these simple queries using operators like 'and' / 'or'. These queries are constructed using Structured Query Language (SQL). ArcMap creates the query automatically in this format.

To create an attribute query, the user must click the Selection menu on the Standard Toolbar. The Select by Attributes option should be clicked. In the Select by Attributes dialog box, the Layer drop down arrow should be clicked and the data layer of interest should be selected.

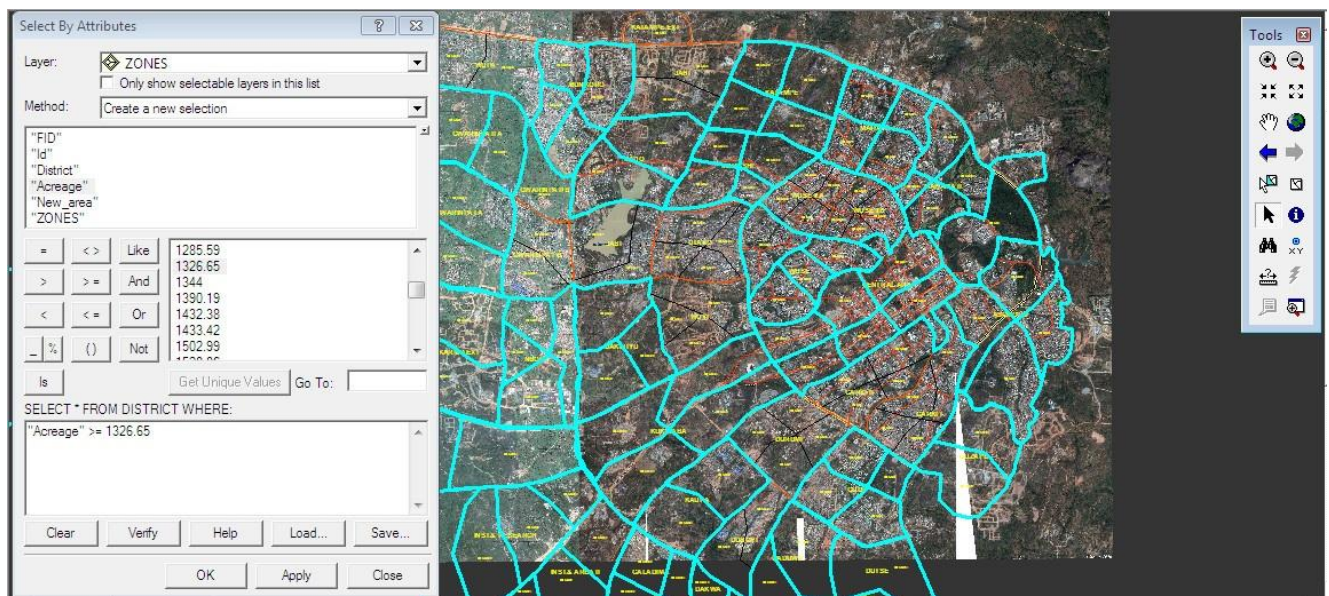


Figure 4.9: Screenshot of Map of Abuja Showing “Selecting Features by Attributes”

The fields in the attribute table appear in the Fields box on the left of the dialog box. When a particular field is highlighted, sample values display in the unique values list on the right. If the

user wishes to see all of the attribute values, the Complete List button may be selected. The buttons in the middle are used to choose operators and to connect queries.

To perform a query, the user must double-click an attribute field of interest, in order for it to display in the bottom portion of the Select by Attributes dialog box. Then the user must click on the appropriate operator button. A unique value of interest may be double clicked on within the Unique Values box, or a value may be directly typed into the query string.

In the following example, all Average were initially selected that had ≥ 1326.65 .

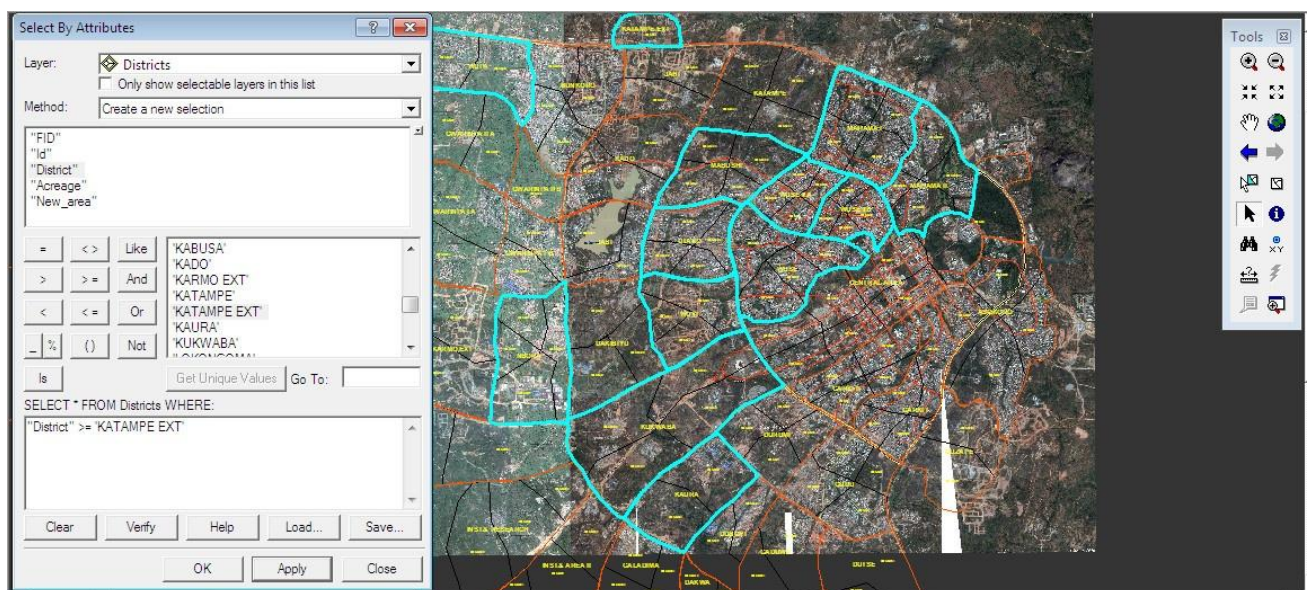


Figure 4.10: Screenshot of Map of Abuja Showing “Performed One Query”

Then, all TAR were selected that had ≥ 1326.65 AND DISTRICT = “CENTRAL AREA”

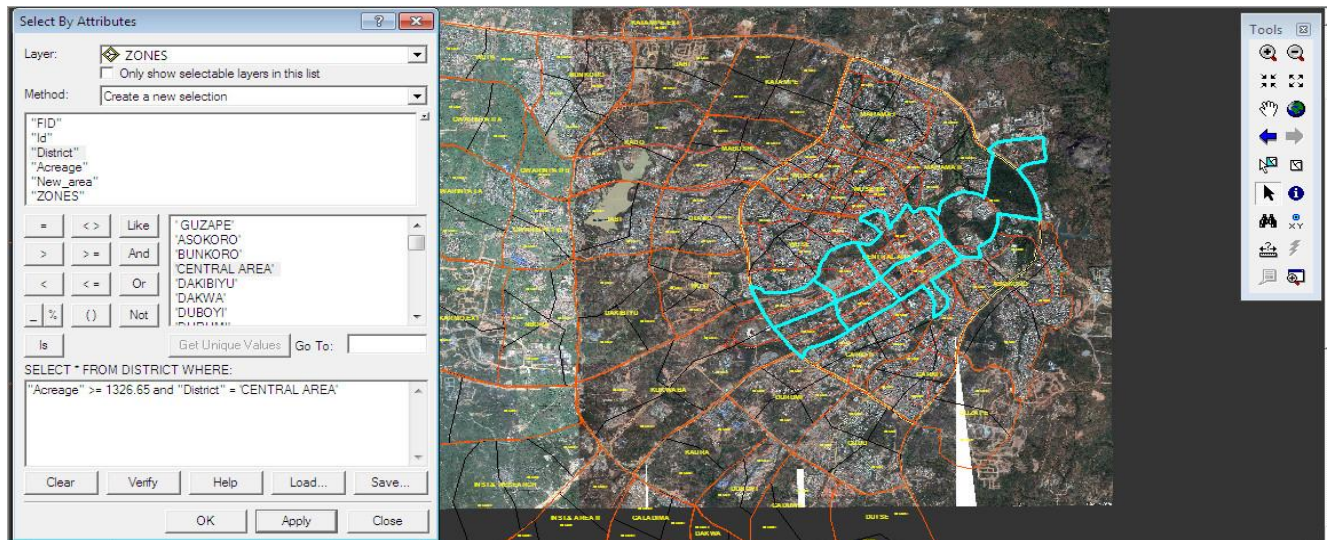


Figure 4.11: Screenshot of Map of Abuja Showing “Performed Two Queries”

4.2.4 Selecting Features by Location: Instead of selecting features by their attribute values, the user may also select them by their location (their spatial relationship to other features, whether in another layer or in the same layer). To select features by location, the user specifies a selection method, a selection layer, a spatial relationship, a reference layer, and sometimes a distance buffer.

To begin selecting features by location, the user must click the Selection menu and click the Select by Location option. The Select by Location dialog box open

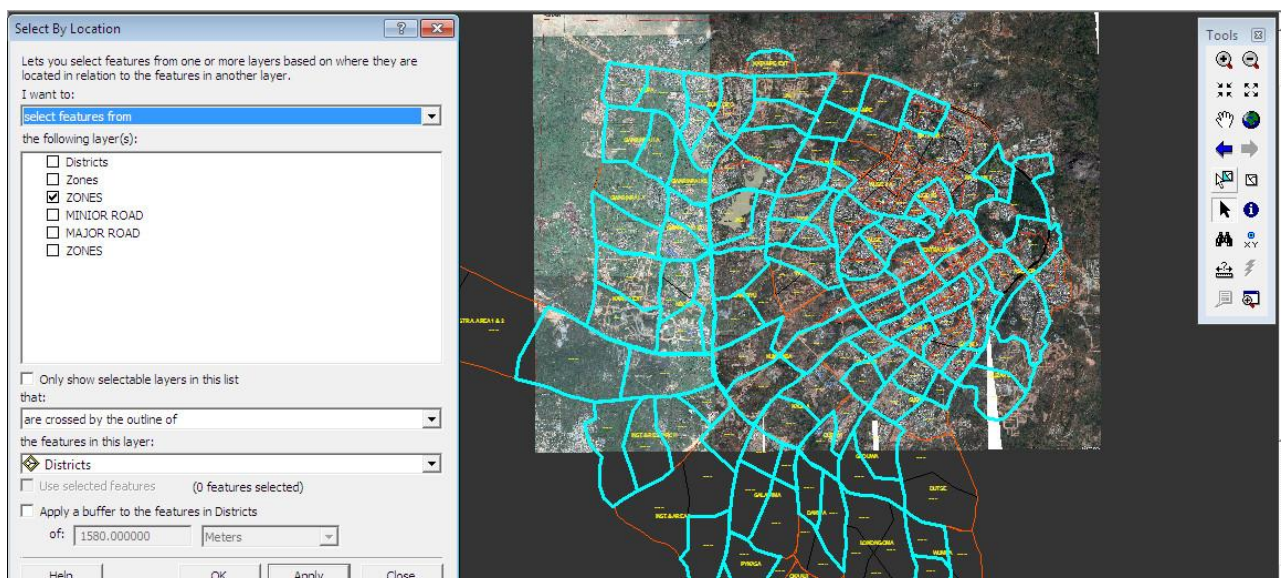


Figure 4.12: Screenshot of Map of Abuja Showing “Selecting Features by Location”

Once a feature has been selected in can be converted into its own ArcMap data layer.

This can be done by right clicking on the name of the data layer in the table of contents that contains the selected feature of interest and clicking on the Create Layer from Selected Features option in the Selection menu the new layer will appear in the table of contents. This layer is given a default name that can be changed by right clicking on the name, selecting properties, selecting the General tab, and typing in a new name in the Layer Name box.

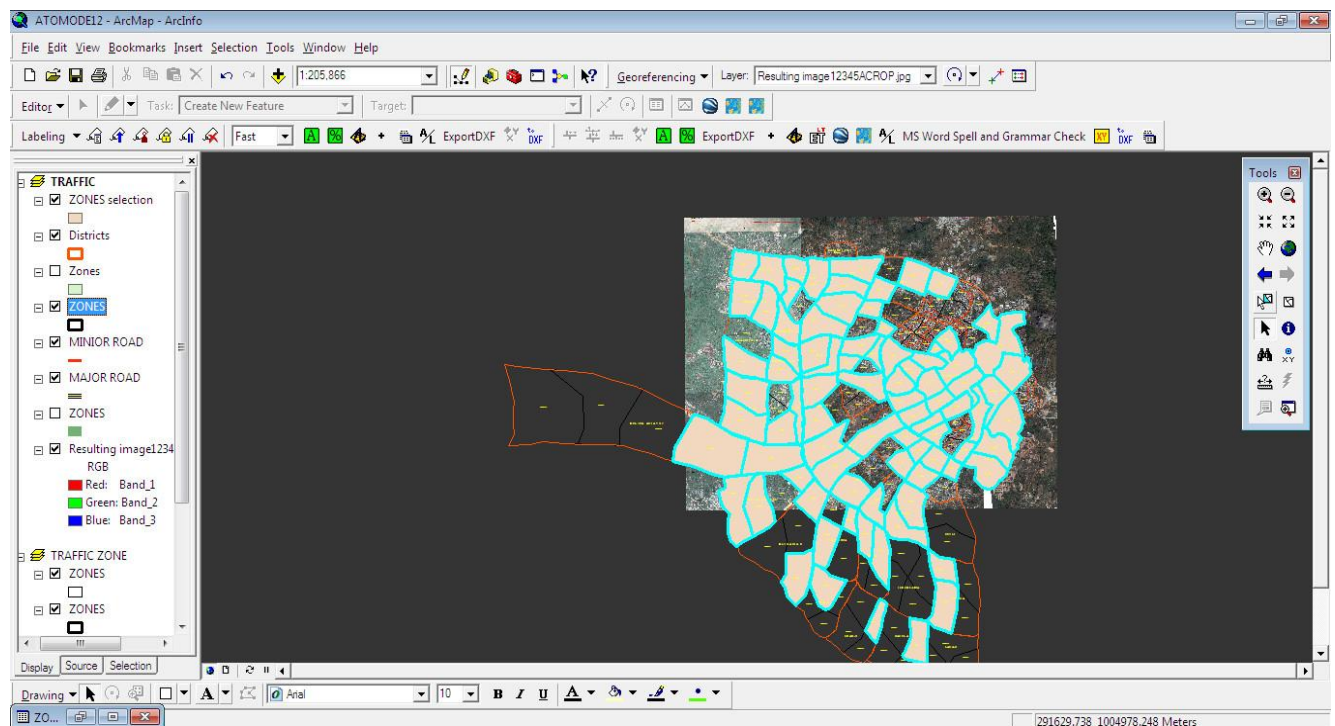


Figure 4.13: Screenshot of Map of Abuja Showing Converted Selected Features into its Own ArcMap Data Layer.

4.2.5 A Typical Example of Desire Line

A typical example of Desire line are show below with attributes of zones matrix desire lines.

OID	ID	LENGTH	DIR	ZONES_ALL1	ZONES_ALL	AB	BA	CORE_ID
0	1	1.23	0	1	2	45	97	0
1	2	1.57	1	1	3	345	0	0
2	3	2.31	1	1	4	23	0	0
3	4	2.5	1	1	5	58	0	0
4	5	3.55	1	1	6	79	0	0
5	6	3.17	1	1	7	45	0	0
6	7	4.36	1	1	8	346	0	0
7	8	4.68	1	1	9	98	0	0
8	9	4.95	1	1	10	243	0	0
9	10	4.28	1	1	11	325	0	0
10	11	3.57	1	1	12	34	0	0
11	12	5.6	1	1	13	23	0	0
12	13	4.92	1	1	14	5	0	0
13	14	4.11	1	1	15	10	0	0
14	15	2.87	1	1	16	23	0	0
15	16	2.74	1	1	17	2	0	0
16	17	3.6	1	1	18	65	0	0
17	18	6.08	1	1	19	9	0	0
18	19	4.13	1	1	20	68	0	0
19	20	7.79	-1	1	63	0	2	0
20	21	1.04	1	1	76	0	0	0

Figure 4.14: Screenshot of Table Showing Attribute of zones matrix Desire lines

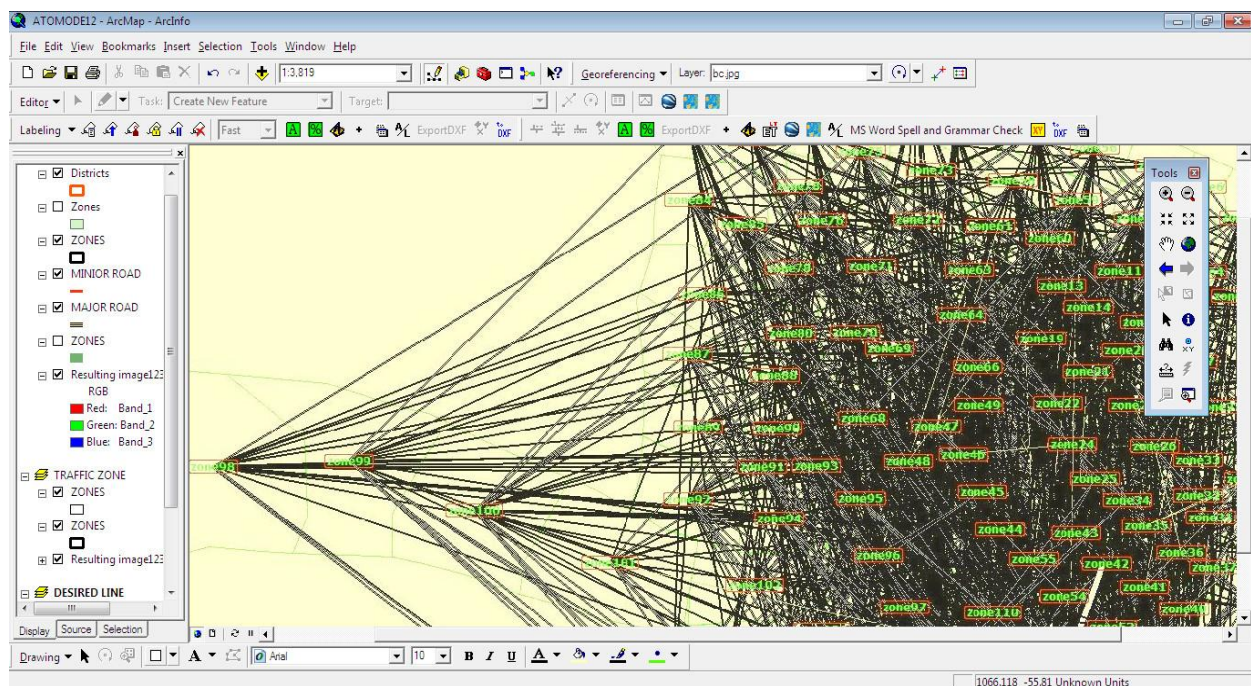


Fig 4.15: Screen shot Showing a Typical Example of Desire lines with Bookmarks view.

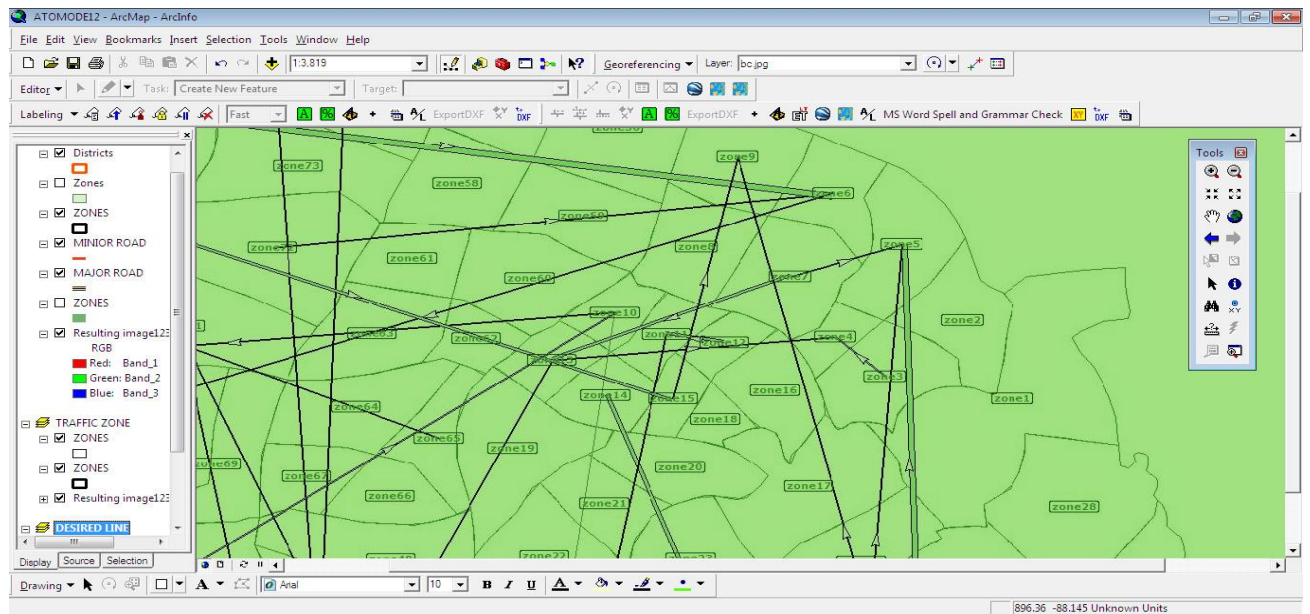


Figure 4.16: Screenshot of Map of Abuja Showing a Typical Example of Desire lines in zoomed style.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATIONS

5.1 CONCLUSION

The discretization of territory and the aggregation of origins and destinations of elementary trips in zone's centroid produce effects on simulation of the transportation system.

In this note these effects have been analyzed through different levels of discretization of the study area (Abuja Municipal Area Council) into traffic zones. The construction of the scenarios of simulation has been made possible thanks to use of a software GIS which has allowed the management, visualizations, aggregations and desegregations of elementary information about both the socioeconomic characteristic of territory and the elements of the transportation system. It has allowed, moreover, a first simple phase of initialization of zoning procedure thanks to the capacity to represent territorial data. The subsequent phases of construction of different zones, for each level examined has been effected on the base of a cluster analysis.

This research has put forth a series of demonstrations developed from the totally disaggregate processing of a large sample household travel survey conducted in the Abuja Municipal Area Council (AMAC) of the Federal Capital Territory (FCT). The substantial role of GIS in facilitating the integration of territory data, road and transit network data (vector and grid) with several transport modeling analysis techniques may lead to a better understanding of the complex equilibrium of urban transport and may suggest new means of managing traffic congestion in the future.

5.2 RECOMMENDATIONS

Following the traffic analysis zoning of FCC and the subsequent creation of the desire line for the origin – destination matrix, the following are recommended.

- i. GIS should be adopted as the basic transportation planning tools for Nigeria.
- ii. The traffic analysis zoning of all the states should be conducted and collated to enhance future traffic planning.
- iii. Alternative routes should be considered in areas of high traffic demands to avoid congestions as highlighted in the desire line.
- iv. Central information center for GIS should be established for easy collection of GIS related information.
- v. Socio-Economic data base should be established and maintained in every state so as to facilitate easy computation of TAZ.
- vi. The traffic Analysis zoning of Abuja should be adopted as the basis for comparison of future traffic analysis zoning.

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