APPLICATION OF GEOGRAPHIC INFORMATION SYSTEM IN MAPPING SOLID WASTE COLLECTION POINTS IN NEW OWERRI, IMO STATE

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A THESIS SUBMITED TO THE POSTGRADUATE SCHOOL

FEDERAL UNIVERSITY OF TECHNOLOGY, OWERRI

IN PARTIAL FULFILLMENT OF THE REQUIREMENT FOR THE AWARD OF MASTERS OF SCIENCE M.Sc IN ENVIRONMENTAL TECHNOLOGY

FEBRUARY 2010

CERTIFICATION

I certify that this research work "Application of geographic information system in mapping solid waste collection points in New Owerri" was carried out by OKORONDU UGOCHUKWU VICTOR (Reg. Number 20085633618) in partial fulfillment for the award of degree (M.Sc) in Environmental Technology in the Department of Environmental Technology, Federal University of Technology Owerri.

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DEDICATION

This research is dedicated to the glory of Almighty God for his mercies and kindness towards its actualization.

Also, to my lovely father Mr. A. D. Okoro and late mother Mrs. A. C. Okoro.

ACKNOWLEDGEMENT

I express my thanks to surveyor Mr. Chinedu and his team from Imo State Ministry of Land and Survey for releasing the layout maps of all the areas in the study area.

Also, not left behind are surveyor Mr. Marscel and town planner Mr. O. Akolan of Owerri Capital Development Authority for their assistance in releasing informations and in decoding land use features on Owerri Master Plan map.

My profound gratitude goes to my supervisor Dr A. O. Nnaji of the Department of Environmental Technology for his encouragement and constructive criticism structured towards achieving effective project.

Finally, I am deeply recognizing the assistance of surveyor Dr Aguwamba of Owerri Capital Development Authority and Mr. Ossai Chuks (Head IGIS) of Imo Geographic Information System (IGIS) for their assistance and also to others who in one way or the other contributed towards making this project a success.

TABLE OF CONTENT

LIST OF FIGURES

LIST OF TABLES

PAGE

ABSTRACT

The unsanitary condition in which solid waste is temporarily dumped and disposed off has generated environmental concern through pollutions and health hazards. This calls for a need to map out suitable collection points and disposal point for effective and efficient management of solid waste to promote hygienic environment.

This study is limited to the new Owerri inside Owerri municipal, Imo State. It focuses on site selection for solid waste collection having considered the existence of waste dumpsite at the eastern and northern part of the town.

The data required were captured through scanning and georeferencing Owerri Street Guide map obtained from Imo State ministry of Land & Survey. The Georeferenced map was digitized using AutoCAD Land Development 2i. The digitized drawing was exported into Arc view 3.2a, where the layers were converted to shape files and then polygonized. Afterwards, attribute tables were created for each land use and finally, the required spatial analyses and queries were performed using the same Arc View 3.2a.

Consequently, different the collection points were identified as points in relation to their coordinate values and layout. The respective coordinate values represent the locations specified by the Geographic Information Systems as well as the attributes of the points. Thus, in all the sited collection points, the distances to similar land use type are the same as stated in the criteria with respective distances of; road=10m, commercial land use=20m, public land use=40m, river >70m and residential land use=20m.

Therefore, GIS offers solution in this regard as a decision support system for most suitable site selection.

CHAPTER ONE

INTRODUCTION

1.1 BACKGROUND OF THE STUDY

The collection and disposal of solid waste is today a major public health issue and an important factor affecting the quality of the Nigerian cities. It is one out of the most intrinsic causes of environmental problems today found mainly in deterioration of environmental parameters (air, land and water quality), perhaps leads to environmental pollution.

The increase in the volume of solid waste being generated daily in most Nigerian cities especially Owerri municipal is due to rapid population growth mostly migrant population, urbanization and general economic growth (NEST, 1991). In many Nigerian cities, the volume of solid waste generated have overwhelmed urban administrators the capacity to plan for its collection and disposal. Thus , in the case of Owerri municipal, major solid waste generated are from residential and commercial activities which has a volume grown recently above planed limits becoming a threat to the initial sufficient and effective collection and disposal of solid waste. The unimaginable rapid population growth together with poor and unsustainable planning has given the municipality less significant and no suitable solid waste collection point prior to be disposed. Solid waste are disposed off indiscriminately often on open spaces such as markets places, road sides “as in Aladimma” and area A of world bank dump, in between dual carriage ways as in Douglas road dump”, streets, river bank, gutters during heavy rain fall etc where it in all causes traffic jam, imposes threats to the health of man and his environs at large.

Wastes especially solid waste has been described by Awosan (2006), as a moveable object which the owner wishes to dispose off in which controlled disposal is necessary to ensure the well being of the general public and in particular the protection of the environment. In addition, Adesida and Igbukwu (1998) described solid waste as any avoidable material resulting from industrial, domestic and commercial activity for which there is no economic demand by the generator which must be disposed off. Thus, solid

waste can also be defined as a residue in solid form emanating from all processes of production, transformation and consumption, which is abandoned or destined to be abandoned by the generator for which can be collected, recovered, , stored, recycled re-used or finally disposed off. However, waste generation borders only few people where as its disposal presents a major headache to both the generators and the various bodies concerned with its management

However, the advent of Geographic Information System (GIS) in Nigeria has paved way for the analysis of point for collection and disposal of solid waste after considering certain factors and criteria's. GIS role in solid waste management is as large as in many aspects of its planning and operation dependent on the spatial data

GIS can be defined basically as an organized collection of computer hardware, software, geographic data and personnel designed to efficiently capture, store, update, manipulate, analyse and display all forms of geographically referenced information (ESRI, 1999). A GIS can be effectively and efficiently used to analyse, model and map any natural or human phenomenon or activity that has geographical dimension. In other word GIS is quite ideal for handling and managing referenced data or information. Solid waste generation is a land-based activity; hence its analyses, visualization and mapping of the volume, frequency, variety and distribution could best be handled by GIS technology. In general, GIS plays a key role in maintaining data accounts to facilitate collection operations, customer service, analyzing optical locations for transfer stations, planning routes for vehicle transporting waste from residential, commercial etc to transfer stations and from transfer stations to landfills and monitoring of land fills. GIS is therefore a tool that reduces the time and cost of site selection for collection and disposal of solid waste and as well provides a digital data bank for future monitoring programme of the site, (Ogra, 2002).

1.2 STATEMENT OF THE PROBLEM

Urbanization and rapid population growth has increased indiscriminately the volume of residential and commercial solid waste generation in Owerri municipal above planned

limit, thereby making the efficient and effective collection, handling and disposal of solid waste a difficult task.

However, new Owerri is an emerging town from Owerri municipal with some areas densely populated producing large and voluminous waste that are dumped illegally on road sidewalks (area A of world bank) and on open spaces. This attitude although is less expensive, imposes higher cost to the society through pollution of air, water and land and may extend to flooding due to blockage of drainage channel. There has not being suitable points for collection and disposal of waste generated by people living in this area.

The efficacy of selecting solid waste disposal and collection points are based on the consideration of three relevant issues namely; Social, Environmental and Economic factors. It is important to determine best waste collection and disposal points based on the efficient consideration of the above three factors. Having seen that the problem of solid waste collection and disposal are spatial problems too, it is therefore the aim of this project to apply GIS in resolving it for new Owerri.

1.3 AIM AND OBJECTIVES OF THE STUDY

The ultimate aim of this study is to apply GIS in mapping out collection point and most suitable site for collection and disposal of solid waste in New Owerri, Imo State.

In order to achieve this aim, the following objectives are followed;

- Designing and creation of digital spatial database “Owerri street guide map” of the study area (data conversion from analogue to digital format).
- Georeferencing and digitization of digital data.
- Identification of roads, rivers and different land uses within the study area.
- Creation of topological relationship between geographic feature and their attributes.

- Setting criteria for the selection of most suitable site for solid waste collection and disposal point.
- Performing spatial analysis such as converting layers to shapefiles, polygonizing, buffering, overlaying union and interception, erasing and querying in order to get the most suitable sites.

1.4 THE SCOPE OF THE STUDY

This study is limited to the new Owerri municipal inside Owerri municipal, Imo State. It focuses on site selection for solid waste collection and disposal, having considered the existence of waste dumpsite at the eastern and northern part of the town,

1.5 SIGNIFICANT OF THE STUDY

To promote the health of man and his environs through a GIS technology approach to solid waste management for efficient and effective determination of most suitable point for collection and disposal of solid waste generated in new Owerri. In addition, to achieve sustainable developmental objectives as well as certifying the saying the health is wealth and a healthy person is wealthy as well.

1.6 STUDY AREA

Imo State is located in the south east of Nigeria. It has twenty seven local government area. New Owerri, the study area is an area within Owerri consisting of part of Owerri west and Owerri Municipal local government areas. Owerri municipal is the capital of Imo state and serves as the central business district of adjourning areas. Owerri is located at longitude 7” 11’ E and 9” 26’ W and latitude 5” 29’ N and 8”41’S.

The study area is new Owerri within Owerri metropolis, Imo State. New Owerri by land mass covers over 55% of Owerri metropolis area. It is located on the south west part of Imo state. New Owerri is bound in the north by new road, Irete, in the east by Old Owerri (along Nworie River), in the south by Nekede (along Otamiri) area and in the west by Umuguma.

New Owerri comprises world bank areas, federal low cost housing estate area, concord hotel areas, new state secretariat area, federal secretariat area, Nekede extension and zoo area, Umugwueze and Umuejechi nekede area, new industrial layout and other layouts identified as Area A, B, C to Y and more.

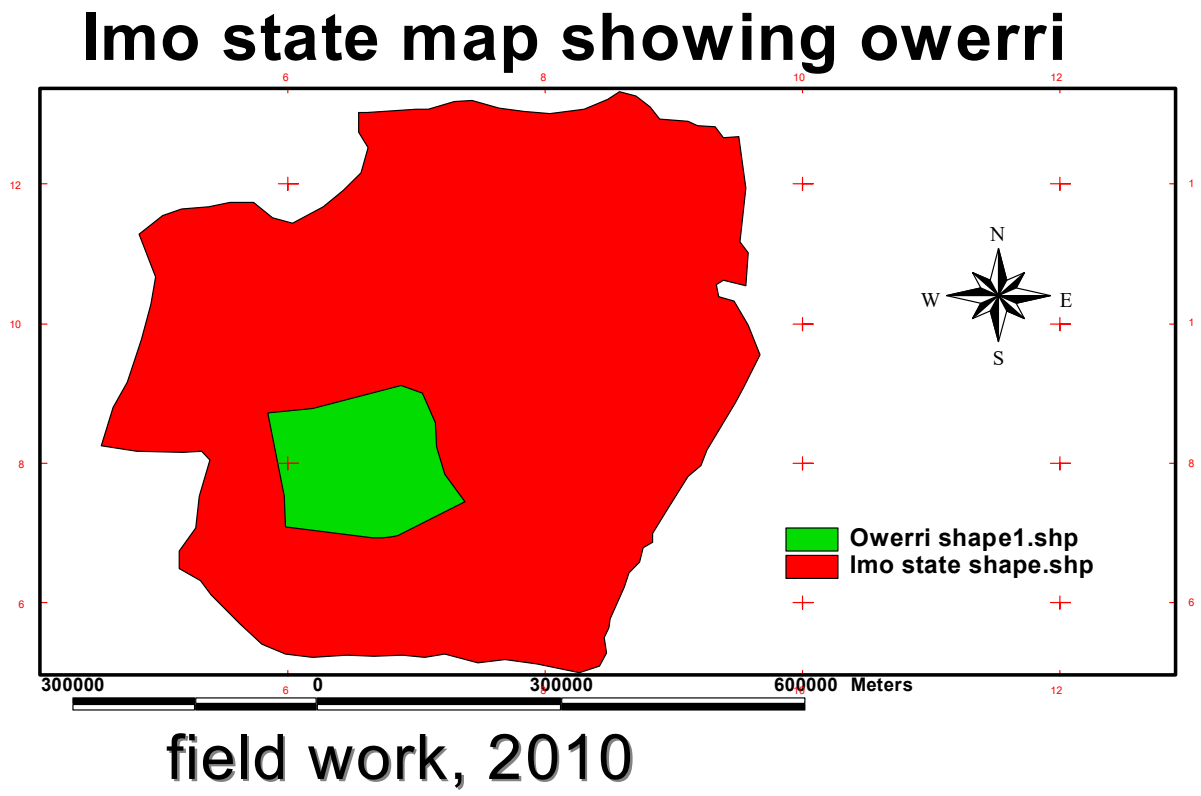

Fig 1.1 Layout map of Imo State showing Owerri area only

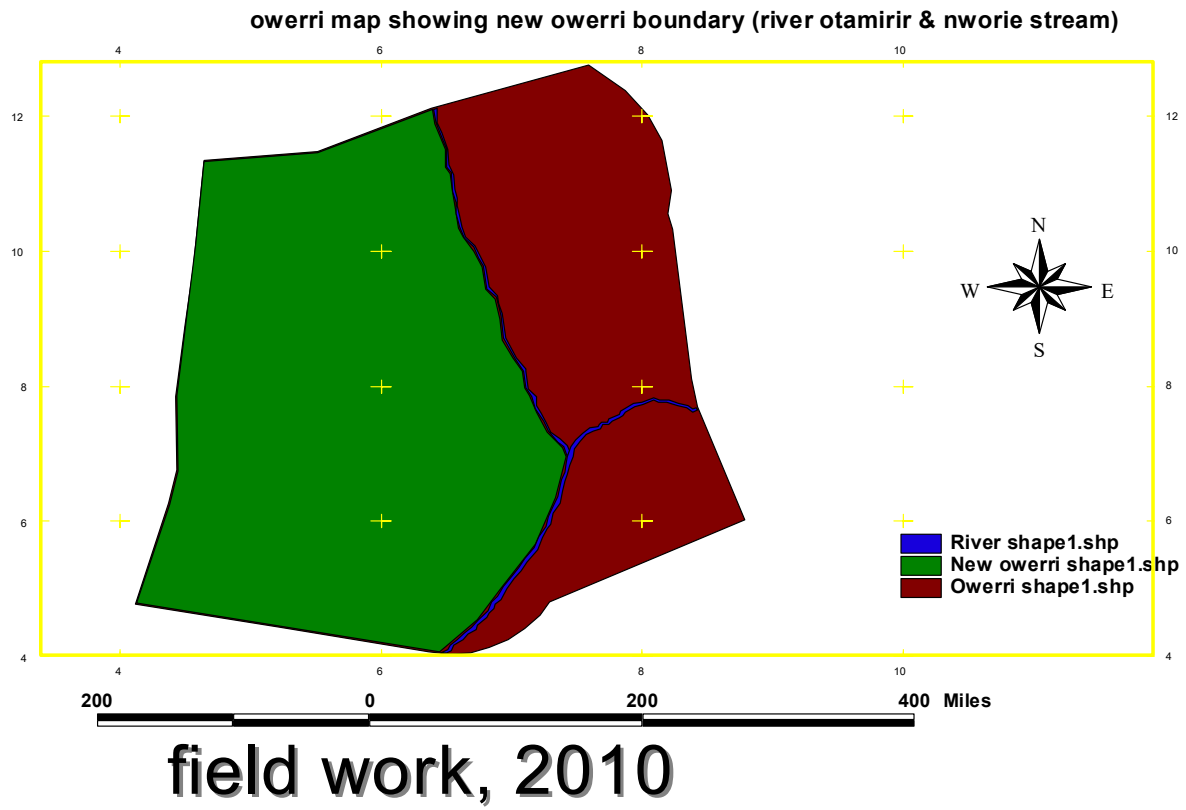

Fig 1.2 Layout map of Owerri showing New Owerri area and river Otamiri and Nworie Stream

1.7 LIMITATION

- The map of street guide otherwise called master plan of Owerri has not been updated since 1976 that the State was created. Thus, the recently developed path of new Owerri has its features and roads not named in the map, making field work a difficult task toward attribute data acquisition.
- Majority of the southern, western and part of the northern side of new Owerri are still big forest, this makes identification of a tangible point for georeferencing difficult.

- The study area was too large consisting of over 30 layouts at a scale of 1:20,000 each which made its mapping a difficult task.
- The large size of the study area made the spatial analysis to be poorly visible in project presentation.
- Financial constraints for the procurement of the necessary hardware and software required for the project as well as expatriate consultancy.
- The problem of mobility during field observation and acquisition of geographic data.
- Problem of securing data from virus and other hardware and software problems.
- Access to data, lack of up-to-date data and incomplete data.

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CHAPTER TWO

LITERATURE REVIEW

2.1 CONCEPT OF SOLID WASTE.

Hornsfal et al (1999) defined solid waste as non liquid, non soluble material arising from human and animal activities, which are discarded as being useless or unwanted. They range from municipal garbage to industrial solid waste that contains complex and hazardous substances. Anderson (1982) sees solid waste as any garbage, refuse, sludge from waste treatment plant or any pollution control facility or any other discarded material resulting from industrial, commercial, mining and agricultural operation and community activities. Olarjinde (2007) describes solid waste as substances or objects discarded as worthless or unwanted, defective or of no further value for manufacturing or production process. Similarly, NEST (1997) in the same opinion added that these unwanted materials are disposed off according to the provision of natural law. Sridhar (1996), defined solid waste as any unavoidable material resulting from domestic and individual material which must be disposed off.

However, Odicha (1994), opined that these materials although disposed off because they are no longer needed here, may be a feedstock or raw material close where. Thus he describes solid waste as materials which are generated as a result of natural operation over which we have control in terms of their production, disposal or discharge.

In general, solid waste is produced by various human activities within a particular place in an environment. Thus, the release of these materials into the environment sometimes causes serious health problems which may preclude usage of our land and water resources. The quantity and character of solid waste varies greatly depending on geographical location, population, food pattern, technology and management. Based on this, solid waste can be defined as a residue in solid form emanating from all processes of production, transformation and consumption, which is abandoned or destined to be

abandoned by the generator for which can be collected, recovered, stored, recycled re-used or finally disposed off, Nkwocha (2010).

2.2 CLASSIFICATION OF SOLID WASTE

According to hornsfal et al, solid waste can be classified as;

(a) Garbage: These are decomposable wastes from food, slaughter houses, canning and freezing industries, animals, fruit or vegetable residues resulting from the handling, preparation, cooking and eating of foods. These waste are also known as putrecible waste, they decompose easily especially during the dry season.

(b) Rubbish: These are non-putrecible waste, which are either compostable or non-combustible. Combustible rubbish waste include paper, wood, cloth, rubber, leather and garden wastes etc while non –combustible rubbish waste include metal glass, ceramic, stones, nails, and masonry etc.

(c) Ashes: These are residues of the combustion of solid fuel from heating and cooking or incineration of solid waste by municipal, industrial and apartment house incinerators.

(d) Large wastes: They include waste from demolition and construction activities. They include pipes, bricks, roofing and insulating materials, automobiles, refrigerators and other home appliances, trees, tyres, etc.

(e) Dead Animals: They include household pets, rodents, zoo animals and other animals killed by automobiles and other means. Also in this group are anatomical and pathological wastes from hospitals.

(f) Industrial Solid Waste: They include chemical, paint, drums, explosives, sludge etc.

(g) Mining Wastes: they include tailing, slag heaps, coal piles at coal mines etc.

(h) Agricultural Wastes: They include farm animal manure, crop residue etc.

(i) Military Wastes: They include e abandoned trucks, tanks explosives, aircraft parts and submarines.

(j) Special Waste: These are waste from street sweeping, roadside letter, catch-basin debris and abandoned vehicles.

Also, Cresser (1983) classified solid waste into (1) Municipal Solid Waste,

(2) Industrial Solid waste and (3) Hazardous Solid Waste.

(1) **Municipal solid waste;**

These are solid waste generated in the municipals or urban areas. They are heterogeneous in nature and can be categorized further into; commercial, residential, sanitational, institutional and artisanal solid waste.

(a) Residential Solid Waste: These are waste generated from household or domestic activities. They include solid food wastes, rubbish, ashes, special wastes etc.

(b) Commercial Solid Waste. These are waste generated from commercial activities such as from stores, hostels, motels, parks, print duplicating shops, repair shops. Theses type of waste includes rubbish, ashes, food wastes, special wastes.

(c) Sanitational Solid Waste: These are waste generates from sanitation activities. They contain a lot of sand and other non degradable material collected from sewer lines (gutter), drainage channels etc.

(d) Institutional Solid Waste: these are waste generated from schools, churches, banks etc. they are dominated with papers, cartons, and a few plastics.

(e) Artisanal Solid Waste: These are solid waste generated by a group of creative people who are not registered with government but are well recognized by them. They include welders, mechanics and carpenters etc. they together generate heterogeneous solid waste such as metals, woods, rubber, containers etc.

(2) **Industrial solid waste:**

These are waste arising from industrial activities and typically include mining waste, special waste, construction waste, agricultural waste and hazardous waste etc.

(3) **Hazardous solid waste**

These are waste that pose substantial danger immediately or over a period of time to human, plant or animal life. These waste, because of its quantity, concentration, physical, chemical, biological and infectious characteristics may cause or significantly contribute to an increase in mortality or an increase in serious irreversible or incapacitating, reversible illness, or pose substantial hazard to the health of man and his environment if improperly treated, stored, transported or disposed off.

According to Nkwocha (2010), a solid waste is considered hazardous when it exhibits any of the following two criteria namely; First, they contain one or more of the criteria pollutants that are chemically identified as hazardous such as sulphur dioxide, nitrogen (IV) oxide, carbon monoxide, hydrogen sulphide, particulate matters (Pm2.5 and Pm10), hydrocarbons and ozone etc.

Secondly, they exhibit criteria that are defined by laboratory test to have at least one of the following characteristic; ignitability or flammability, corrosivity, reactivity, toxicity and radioactivity.

(i) Flammability (Ignitability); these are materials with flash point below 60oC. They are easily ignited and burns persistently and vigorously and are friction sensitive substances.

(ii) Reactivity; these are waste that are unstable at room or normal temperature conditions. They can form toxic fumes on reaction with water and can explode on other reactions.

(iii) Toxicity; these designates that a specific quantity of substance can cause damages to living organisms at a specific condition. Toxicity can be defined by four major criteria such as; Bioaccumulation- this is the ability of a substance to be retained

in the living tissues of animal up to higher trophic levels in the food chain where it causes health hazards. E.g. pesticides plants can be transferred from herbivores to man.

Lethal Dose at 50 (LD50) - this is a measure of the amount of chemical that is needed to kill 50% of the entire population or specimen in a bioassay.

Lethal Concentration at 50 (LC50) -this is a measure of the concentration at which 50% of animals in a bioassay dies. It is used especially in aquatic environment where the amount measured cannot be determined.

Phytotoxicity -this is a measure of the degree of toxicity of chemicals to plants.

(iv) Radioactivity; this are substances that can undergo spontaneous disintegration (fission) of their atomic nuclides to attain stable configuration and as well form other compounds which are considered hazardous to man and other living organisms. Virtually, all nuclear reactors rely on Uranium fuel reactions to form element such as plutonium-90, americium-95, curium-96,, theorium-230, radium-226, radon-222 and lead-210 etc, all which causes cancers, mutations, gene destructions and death.

Nkwocha (2010) had a similar view to Cresser, (1983) in solid waste classification. He however, added (Agricultural and Bulky solid waste to Cressor classification. Thus, he describes them as follows;

Agricultural solid waste:

These are solid waste generated from agricultural related activities. They includes solid waste from repairs and maintenance of agricultural equipments, abattoirs, pigres, farming, poultry etc. most agricultural solid waste are biodegradable and are easily recycled.

Bulky solid waste:

These are solid waste that are bulky in nature and are non degradable. They contribute most to the ugly look of the town. They include; spoilt refrigerator, television, abandoned vehicle and furniture.

However, he contributed to Cressor classification of solid waste as “Industrial Solid Waste” by sub classifying it into three namely; (a) inert solid waste (b) diverse solid waste and (c) hazardous solid waste. In his explanation, he defined the various solid wastes emanating from industrial sector as;

(a) Inert Solid Waste: These are solid waste that cannot physically, chemically or biologically pollute the environment. They are natural in-offensive, innocus. Their physiochemical and biological properties render them inert. They include waste from the demolition and construction industries, stones, graves, woods, roofing materials like zinc, aluminum, nails etc.

(b) Diverse Solid Waste: These are solid waste generated from industrial complexes such as industrial canteens that generates food waste, plastics, cans, papers etc, and
(c) hazardous solid waste was in the same opinion to Cressor (1983) view.

2.3 PROPERTIES OF SOLID WASTES

The properties of solid waste is essential for its effective management by evaluating an alternative plans, proposals, management programme and equipment needs, with respect to the implementation of disposal and resource and energy recovery option. The properties of solid waste relevant for its management are classified into physical and chemical characteristics (Visilind and Pierce 1982, Cressor 1983 and Oluwande 1985).

Physical characteristics

According to them and Fifield and Haines (1995), the physical composition relevant for physical characterization of solid waste includes;

(a) Individual component of solid waste

(b) Particle size analysis

(c) Moisture content analysis

(d) Density of solid waste

(a) Individual Component of Solid Waste; this is obtained by sorting out the identifiable waste into its individual content present to obtain percentage of each component in the entire bulk.

(b) Particle Size Analysis of Solid Waste; this involves the use of similarity in sizes of solid waste as a technique for the recovery of the material; this can be achieved mechanically with screens and magnetic separators.

(c) Moisture Content Analysis; this is a measure of the moisture content of solid waste usually expressed as the mass of moisture per unit mass of dry material. In wet-mass method of measurement, moisture content of solid waste is expressed as the percentage of the wet of mass of material. However, in the dry-mass method, it is expressed as the percentage of the dry mass of material. Using equation, the wet mass moisture content is expressed as follows;

For municipal solid waste, a moisture concentration of 20% is usually considered normal. It can vary between 15% and 30% of water.

Moisture content (%) on wet basis; $M = (a-b)/a * 100$

Source (Uchegbu, 2002)

Where a= initial mass of sample as delivered, b = mass of sample after drying

To obtain the dry mass, the solid wastes materials are dried in an oven at 77oC for 24 hours. This temperature and pressure is used to deliberate the material completely and to limit the vaporization of volatile materials.

(d) Density of Solid Waste; the density of solid waste varies remarkably with geographical location, seasons of the year and length of time in storage. The density of solid waste is given by the ratio of solid waste to its volume.

$$\text{Density of solid waste} = \frac{\text{mass of solid waste}}{\text{Volume of its content}}$$

Chemical composition;

The chemical composition of solid waste is important in evaluating the alternative processing and energy recovery options. According to them and Uchegbu (2002), the property of solid waste relevant for this characteristic includes;

(a) Proximity Analysis

(b) Fusing point of Ash

(c) Heating (Energy) Value and

(d) Chemical Content such as Carbon, Hydrogen, Sulphur, Nitrrogen.

(a) Proximate Analysis ; this involves the following;

- Moisture (loss at 105°C for 1 hour)
- Volatile Matter (additional loss on ignition at 950°C)
- Ash (residue after burning)
- Fixed Carbon (remainder)

(b) Fusing Point of Ash;

This involves ultimate analysis, percentage of carbon, hydrogen, oxygen, nitrogen sulphur and ash.

(c) Heating (Energy) Value

This is the energy content of the solid waste. It is calculated by using Kj/Kg (dry Basis) = Kg (as discarded) $\frac{100}{100\text{-\%moisture}}$

The corresponding equation on an ash free dry basin is Kj/Kg (ash free dry basis) = Kj/Kg discarded % moisture = $\frac{100}{100\text{-\%ash-\%moisture}}$.

Energy content = total energy/basis of mass sample of waste (Kg)

(d) Chemical content

The chemical content of solid waste is obtained by ultimate analysis using the modified Dulong formula as;

$$Kj/Kg = 337C + 1428 (H-O) + 9S/8$$

Where C = carbon present

H = Hydrogen present

O = oxygen present

S = Sulphur present

Source: Horsfall (etal) 1998.

2.4 EFFECTS OF SOLID WASTE

It is true that most of our major urban areas and towns are faced with the effects of solid waste. For example, some places in Surulere, Lagos have now turned to a slum as a result of garbage disposal problems which now constitute the greatest nuisance to the environment of the area (Muenchen 1968, Mabogunje, 1976 and Sule 2001).

Sule (1981) attributed the cause of the environmental deterioration of Nigerian cities to lack of proper management of solid waste due to poor administration of urban centers. From his words, it has been observed that researchers concerned with solid waste

disposal in Nigerian cities have not sufficiently related the problem to the production of consumer goods and the disposability of the parts that end as waste. He also wrote on pollution effects of solid waste on streams. He asserted that the life sustaining capacity of a river depends upon the levels of dissolved oxygen as well as the toxic concentration, acidity and other factors. He explained that when organic waste is added to water, oxygen consuming bacteria begins to decompose the waste, thereby reducing it to its chemical constituents and lowering the river's level of dissolved oxygen in the process. Thus, the practice of accumulating and dumping waste in streams must be weighed against the need for increasing the water resources in the areas.

Among the obvious effects of solid wastes are the aesthetic problems and the air pollution caused by unsatisfactory means of disposal. The portion of the earth's atmosphere available to dilute air pollution is confined to a bottom-layer about six miles thick (The committee on pollution 1966). The practice of leaving landfills uncovered and the burning of the waste therein often produce large quantities of smoke and odour which when too much in the air forms a thick cover or blanket which may retard the rate of radiation from the earth's surface. It has also been proved by environmental scientists that decomposing waste omits hazardous gases into the atmosphere such as sulphur-dioxide and methane which are injurious to health.

Although data on the pathogenic nature of municipal solid wastes are meager, the role of solid waste in the transmission of bacteria, virus and parasites is well known. It has been reported that the parasites; Trichiuris trichiuria and Ascaris Lumbricoidas are the most common intestinal parasites found in solid waste from slums and low income neighbourhoods (Njoku, 2010). He further stated that some of the communicable diseases are; fly borne diseases such as typhoid, dysentery, diarrhea, salmonellosis and helminthiasis. Rodent – borne are histoplasmosis, virus infection and relapsing fever and those of mosquito-borne are malaria, yellow-fever, filariasis and encephalitis.

Other effects of mismanagement of solid wastes are;

- They cause flooding when dumped in water ways e.g. the Ogunpa flood disaster

in Ibadan.

- They obstruct free flow of traffic when dumped on highways or city streets.
- Underground water could be polluted either by vertical leaching or by Percolating water with the transfer of gas e.g. carbon dioxide, methane etc.
- Smoke, particulate matter and gases released into the atmosphere via burning of open dumps result in acid aerosols and acid rain which eventually have corrosive effects on buildings, toxic to plants and aquatic life and has harmful effects on human health (Okpala, 1986).

Sule (1995) also collaborating with Ogedengbe (1998) stated that the effects of solid waste mismanagement include;

(i) Public health hazards (ii) Aesthetic objections and

(iii) Occupation of space

2.5 SOLID WASTE MANAGEMENT

Njoku (2010) defined solid waste management as the application of strategies to reduce the solid waste generated to the barest minimum. Nkwocha (2002), describes solid waste management as the process by which all solid waste produced in an area are identified, collected, treated or finally disposed off in a hygienic manner. He further added that for proper management of solid waste, effective plans are required inline with information's and data's on the expected composition and quantity of solid waste generated at a particular area. Thus , the direct activities that must be considered and coordinated on a daily basis includes; waste generation rates, storage, collection, transfer and transport, processing and recovery and disposal. In addition, Earth Watch, (2000), added that the indirect activities that must be considered includes; financing, operations, equipment, personnel, cost accounting, and budgeting, contract administration, ordinance and guidelines, bills and low public communications.

2.5.1 Objective of solid waste management

Nkwocha (2002), stated that solid waste management has two principal objectives; first is to remove the discarded material from inhabited places in a timely manner to prevent the spread of diseases so as to minimize the likelihood of fires and to reduce aesthetic insults arising from petrifying organic matter. Second, is to dispose the discarded material in an environmental friendly manner. Adoki (1993) stressed that; the overall objective of solid –waste management is to minimize the adverse environmental effect caused by indiscriminate disposal of waste especially hazardous waste. Sule (1995) also collaborating with Ogedengbe (1998) stated that the objectives of solid waste mismanagement includes the mitigation and control of public health hazards, aesthetic objections and improve the occupation of space of human beings.

2.6 SOLID WASTE GENERATION

Nkwocha, (2002) defined solid waste generation as the quantity or volume of solid waste produced in a given geographical area at a particular time or in a given period of time which could be a day, week, month or year and for which can be measure in kg or in tones. Waste generation are the activities leading to identification of materials as no longer having a value and are therefore liable to be discarded or disposed off. Solid waste is generated at every process of mining of raw materials, processing of raw materials to be converted to good and consumption (Nkwocha, 2002). The quantity of municipal solid waste generated is influenced by the following factors; geographical location, season of the year, collection frequency, type of food consumed, characteristics of populace, extent of salvaging and recycling, public attitude and population, (Nwadike, 2004, and Njoku 2010).

However, the rate of solid waste generation increases with increase in industrialization, population growth, urbanization, and technological advancement, (Njoku 2010).

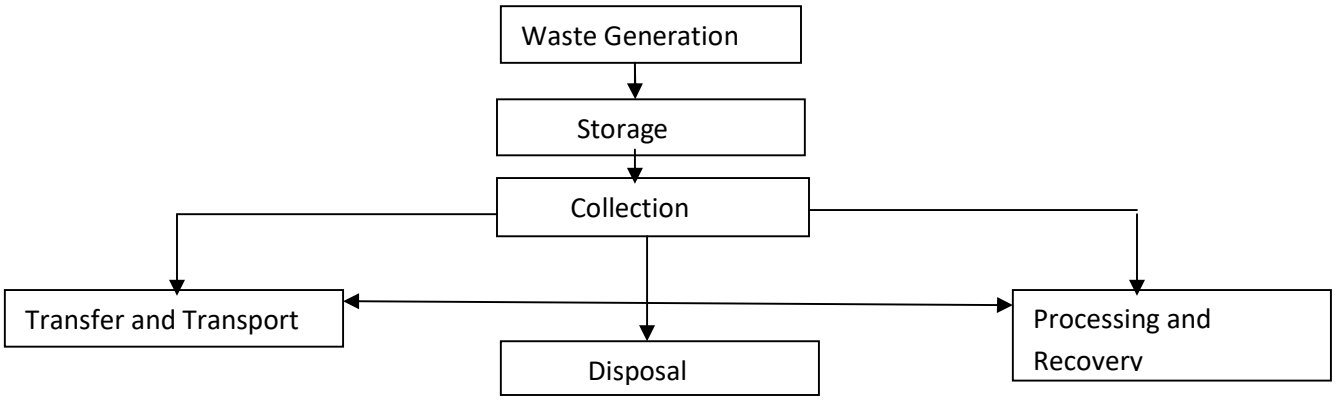

Fig 2.1 The Functional Elements of Solid Waste Management System

2.6.1 Solid waste generation in Nigeria

There has been a phenomenal increase in the volume and range of solid waste generation in Nigerian cities in the past few years. This is due largely to increase in population growth, urbanization, economic growth and the enormous cost involved in solid waste disposal and non-satisfactory depository sites, Njoku (2010).

Nest (1991) estimated 20kg of solid waste per capita per annum in Nigeria, which is equivalent to 2.2 million tons a year. Nwankwo (1991) estimated solid waste accumulation across Nigerian cities at 200 metric tons per year and 6 million metric tons in the next 20 years.

In Lagos, Lagos Waste Management Authority (LAWMA) put solid waste generation per head at 0.68kg and 244,000 per head per month and 2,937,600 metric tons per year for the city. The state government (Lagos) budgeted 600 million naira in1999 to manage this waste (Champion, 1999).

Abumere (1983) in his survey of fifteen Nigerian cities noted that the variation in solid waste volume within the cities is as a result of the Central Business District (CBD) and also residential areas in Nigeria which generate the highest volume of refuse. He therefore, asserted that as distance increased from the city centre the volume of these wastes generated tend to decline.

According to Maduike (2000), "in the past, the use of polythene bags and wrappings were not common because the technology for their production at that time was not known or available, people were only used to materials, such as leaves and papers which are biodegradable. Recently, however, the use of polythene bags and wrappings for storage, preservation and take away of such food items as bread, water and other household items is one of the factors that has contributed immensely to solid waste generation and environmental degradation". However, the usefulness of polythene bags and wrappings in promoting hygienic health and portability of items by urban dwellers cannot be overlooked. According to Durozoechi et al (2003), the 1997 Annual Report of Owerri Municipal Council shows that about 350 – 370 tons of refuse is generated per day in the city. During the fruits seasons, as well as festivals such as Christmas, the figure reaches 400 – 420 tons per day.

Generally, there is a direct relationship between the rate of solid waste generation and population trend, thus urban centers will continue to make extensive demand on urban services such as solid waste management amongst others. Table 2.1 illustrates estimated and projected volumes of solid waste generation in selected cities in Nigeria (Akinbami et al., 1996).

Table 2.1: Estimated projected volumes of solid waste generation in selected cities in Nigeria; figures in metric tons (Akinbami et al., 1996).

City	1982	1985	1990	2000
Lagos	625399	681394	786079	998081

Ibadan	350823	382224	440956	559882
Kano	319935	348580	402133	535186
Kaduna	257837	280925	324084	431314
Onitsha	242240	283929	304477	386593
Port – Harcourt	210934	229821	265129	352853
Oshogbo	131903	143712	173720	253841
Aba	133903	143712	169719	236703
Jos	99871	111905	135272	197660
Warri	97477	75605	91396	133531
Gusao	44488	48471	57243	79835
Uyo	12508	13628	15721	20923
Suleja	9383	10514	13311	21336
New Bussa	5960	6200	7152	9518

2.6.2 Estimating the quantity of solid waste generated

The quantity and general composition of solid waste generated is of great importance in the design and operation of solid waste management system. The waste generation rates may be estimated by the following methods;

1) Load Count Analysis; this is a technique in which the quantity and composition of solid waste generated are gotten by recording the volume or capacity of load delivered to the landfill or transfer station by a truck during a specific period of time. In this method, the amount of solid waste is measured by the quantity carried by a given capacity of lorry. However, this does not give the quantity produced at households. Nkwocha, (2002).

2) Mass volume Analysis; this is a method in which the mass of solid waste distributed is known by recording their weight which is divided by the volume of its container to be expressed using average density, Bartsch et al 1995.

3 Sampling Method; this method gives the quantity of solid waste produced at households. It is achieved by monitoring the quantity and taking an average among the quantity produced at household. The estimated amount is gotten by multiplying the average amount produced at household by the entire population of the area. For instance, estimated amount of solid waste produced in a school can be gotten by measuring the amount produced by each student and taking the average of student product which is multiplied by the entire population of the school. Nkwocha, (2002.)

According to him, mathematically, it can be estimated using the compound formula,

$P_n = P_o (1 + r/100)^n$

Where; P_n = estimated amount of solid waste produced by a particular population at a particular time or year,

P_o = initial quantity of solid waste produced by a particular population at a particular time or year,

r = the rate of growth of the population

n = number of interval. (Source, Nkwocha, 2002).

Example of solid waste quantity estimation using Nkwocha's technique.

If by 2000 census, the population of Imo state was estimated to be 3.6million with the growth rate of 2% per year and the average amount of solid waste production rate per year is 0.6kg. The estimated quantity of solid waste produced in 2010 can be calculated.

Thus,

$P_{2010} = P_{2000} (1 + 2/100)^n = 3600000 (1+2/100)^{10} = 4388379.9$ is the population at 2010.

Then, the estimated quantity of solid waste generated by 2010 is given by 0.6kgX4388379.9= 26330327kg.

Supposing the waste generation rate is expected to increase by 25% in 2010,

The present waste generation rate at 2010 will be given by;

(25/100 X 0.6) + 0.6 = 0.15 + 0.6= 0.75Kg.

Estimated quantity of solid waste therefore becomes; 0.75X365698 = 274273.5Kg.

2.7 ON-SITE HANDLING, STORAGE AND PROCESSING (HSP) OF SOLID WASTE

Onsite refers to the activities associated with the handling, storage and processing of solid waste at or near the point of generation, until they are placed in the containers used for their storage before collections, Nwadike,(2004). The types and capacities of the containers used in on-site storage depends on the characteristics of the solid waste to be collected and frequency of collection and the space available for the placement of the containers Nkwocha,(2002). On-site processing of solid waste is used to recover reusable materials from the solid waste, to reduce the volume or alter the physical composition. Common processes on on-site processing include manual sorting, compaction and incineration, Pat Levson, (1978).

2.8 SOLID WASTE COLLECTION

This is the gathering of solid waste and the hauling of collected waste to approved site for processing or disposal Nwadike (2004). Most of the operational cost in solid waste management is in collection Salvato (1991). He puts the cost estimate to represent about 80% of the total cost in disposal by sanitary landfill and 60% when incineration is used. In view of the cost involved, Ogedengbe (1998), was of the opinion that three fundamental questions often arise namely;

(a) Who shall collect the waste? (b) How should to be collected? and
(c) When should collection be done?

He added that to address the above questions, a municipal authority may use direct labour (i.e. staff), contract it to a private organization or leave it in the hands of individual households who would be expected to make their own contract agreements with private companies.

2.8.1 Collection system and equipments

Various types of collection system are used in municipal for collection of solid waste generated. According to Nkwocha, (2002), they can be classified into; (a) Waste Bins, (b) Waste Bags and (c) Collection Vehicles.

(a) Waste Bins; these are used at homes and on public areas for temporary dumping of solid waste. Modern waste bins contain different spaces separated from different kinds of waste which are indicated by the use of different colours painted on the bin.

(b) Waste Bags; this are used to minimize littering of refuse and odour of biodegradable solid waste within a house hold. They are kept in public places like in amusement parks. Waste bags are more modern than waste bins and do not occupy more spaces.

(c) Collection Vehicle; these are means of transport of solid waste from temporary stored place to processing or disposal points. In undeveloped countries, collection vehicle includes; bicycles, tricycles, wheel barrows, hauling carts while in developing and developed countries, collection vehicles includes; open trucks, tippers, lorries, enclosed trucks and compactors with some equipped with loading devices.

Based on mode of operation, there are two categories of collection vehicle system namely;

(i) Hauled Container System HCS; in this method, the container used for storage of solid waste are hauled to the processing or disposal site, emptied and returned either to their original location or another location. HCS are of two types; tilt-frame HCS and Trash trailer HCS.

(ii) Stationery Container System SCS; these are collection system in which the container used for the storage of solid waste remain at the point of generation, except when moved for collection of solid waste. The two types of SCS are; the one in which self loading compactors are used and the one in which manual loading vehicles are used.

2.8.2 Collection routes

These are routes laid out to enable the workforce and equipment to function effectively. According to Peary et al., (1986) and Nwadike, (2004), the layout of collection route follows a four-step process;

First, location maps are prepared on large scale showing the area to be serviced. Also, the following are plotted for each solid waste pick-up; location point, number of containers, collection frequency and the estimated quantity of solid waste to be collected at each pick-up location if a stationery container system is used.

Second, data summaries are prepared containing the estimated quantity of solid waste that can be collected at each pick-up location serviced daily and the determined number of location that will be serviced during each pick up cycle.

Third, the preliminary collection routes are laid out starting from dispatched stations or where the collection vehicles are parked to the last location nearest to the disposal point.

Fourth, a balanced route is developed incorporating the haul distance for each route after preliminary route has been laid out. Also, the labour requirement per day, work times per day, and the lost solid waste transfer and transport locations are determined.

2.8.3 Transfer station

Transfer stations may be divided into three namely according to eliington, 1989; the direct discharge, storage discharge and combination of direct and storage discharge.

Direct Discharge: in this station, wastes are transported from collection vehicle to another vehicle usually trailer for conveyance to a final disposal point.

Storage Discharge: in this method, wastes are transported from collection vehicle to a storage pit or onto a platform from which they are headed into transport vehicle for final disposal.

Combined Direct and Storage Discharge: in this method, collection vehicle discharges their waste to either another vehicle at its availability or to a storage pit or platform from which it can be collected and disposed to final disposal point. This method saves the time collection vehicle will wait to unload.

2.8.4 Methods of collecting solid waste in Nigeria

The method of collection adopted in Nigeria depends on the layout of the community Njoku (2010). Where the community is well laid out with access roads, each household is provided with a standard refuse container. According to Nest (1991) as cited by Okechukwu (1995) reported that there are virtually no bye-laws specifying the type of containers to be used in the collection and storage of refuse – thus individual households use inappropriate containers – such as non-durable empty cartons, local baskets, plastic and metal bins. These containers filled with refuse are placed at designated location easily accessible to the collection crew. In many instances, the container, filled with refuse is removed to a waste depot within the neighborhood.

The frequency of collection depends on the volume of waste generated, the efficiency of the agency; time of the year and the socio-economic status of the community (Salvato, 1991). In some advanced societies, separate containers are provided for different types of solid waste. Salvato (1991) recommended solid-waste collection in business districts

to be daily except on Sundays, twice in residential areas during warm months and once in other months of the year..

The four main methods adopted by local government and state waste management agencies in Nigeria are house-to-house, communal depots, curbside collection and block collection (Okorie, Nwagwo, 1993 and Nkwocha, 2002).

1. *House-to-house collection*: This is practical in residential layout and other well planned areas in the city. This method is more common in high-income, low density residential neighbourhood.

2. *Communal depots*: Depots are generally placed or designated in areas of dense population concentration with heavy volume of waste generation. Communal waste storage is located mainly by the roadside or other areas with vehicular access. Most local governments and agencies adopt the depot method over the house-to-house method because of its convenience and affordability.

3. *Curbside collection*: Road-side and open spaces are usually used for depositing bin and other containers for refuse from where they are emptied. This can be adopted where depots are non-existent but solid waste generation is high.

4. *Block collection method*: This involves the ringing of a bell by the waste collectors. As the bell is ringed, household members bring their waste and throw it into the waste collection vehicle or truck.

2.9 SOLID WASTE PROCESSING

This is a technique employed in solid waste management system to improve the efficiency of solid waste disposal system, to recover reusable material and to prepare material for conversion into other products and energy Hornsfall et al (1998). According to him, various processing techniques are;

Manual component separation: This is the manual separation of solid waste generated into its similar components. This can be accomplished at the processing station or at disposal site. Also mutual sorting at the source of generation helps to

improve the recovery and reuse of material. The number and type of material sorted depends on the location, opportunities for recycling and resale market.

Mechanical volume reduction: This is a technique in which the volume of solid waste generated are reduced mechanically using compactors usually collection vehicles equipped with compaction mechanisms. This method is very important in solid waste management system.

Mechanical size reduction: This is a technique used to obtain a solid waste at final product that is of reasonably uniform and reduced in size in comparison with its original form. However, in some situation, the total volume of the material after size reduction may be greater than the original volume.

Thermal volume reduction: This is the use of incineration technology to reduce the volume of combustible solid waste generated. Incineration reduces the volume of solid waste to about 90%.

Magnetic and electromagnetic separation: this is a technique used to separate ferrous material from non ferrous metals associated with solid waste through magnetic separation. Non ferrous materials are removed by a variety of electromechanical technique.

Drying and dewatering: this is a technique used in drying the shredded fraction of solid waste to reduce its weight. This technique enhances incineration and energy recovery technique.

2.9.1 Recycling of solid waste

This is currently the most pursued method of solid waste processing and treatment. The materials are sorted out before recycling can be carried out effectively. Transportation is a major factor in the realization of recycling and can adversely affect the willingness of manufacturers to use the second grade raw material if the cost is high. Solid waste materials like glass, paper, plastic, tyres etc can be recycled into new products.

According to Ogendegbe (1990), the following possibilities exist:

(i) Salvaging metals, papers, glass etc, from abandoned automobiles, refrigerators, television sets etc.
(ii) Production of biogas from the biodegradable components of solid waste.
(iii) Pyrolysis of waste to produce an alternative source of heat energy to coal, wood, etc.

The practice of recycling of solid waste is an ancient one. Metal implements were melted down and recast in prehistoric times.

2.9.2 Resource recovery

This is the process of turning what has been considered as waste into useful product for use. Wilson (1981) observed that we are going into the period of energy crisis and the possible way of remedying the situation is the process of converting the so called waste and other sources of biomass into useful materials.

2.10 SOLID WASTE DISPOSAL

This is the final rest in place for solid waste generated. Hornstone teal (1998) defines solid waste disposal as the final placement for toxic, radioactive, pesticides, chemicals and hazardous material using approved methods. (Nkwocha 2010), with similar opinion defines it as the forever elimination of solid waste. According to them, various technique employed includes;

Deep well injection: This is the injection of solid waste deep in the ground into impermeable rock formation or underground caverns. This method is common and most practiced by oil and gas industries in disposing the hazardous solid waste generated.

Sanitary landfill: This involves a designed and controlled disposal of solid waste solid waste in the upper layer of the earth's mantle in such a manner that water ground quality, air quality and surface water quality are protected. Deposited wastes are usually spread and covered with a required quantity of earth materials which are compacted after each days trip (Wilson, 1983). The sitting of sanitary landfill are subjected to EIA

approval with implementation based on the consideration of the following factors; (1)land-filling methods and operations (2) control of the occurrence and movement of gases and leachate (3) nature of soil for site selection and

(4) ground water table/saturate aquifer dept.

Sanitary landfills are equipped with underground water monitoring gadgets to checkmate the infiltration of leachate, ground water and any saturated aquifer. .

Incineration: this is a process for high temperature oxidation of solid waste. The burning of solid waste at high temperatures leaves ashes, carbon dioxide, water vapour and non combustible materials behind as products. The flare gases are released in the atmosphere with or without recovery of the heat and the ash produced may be deposited in a landfill. Air pollution is often the problem with incineration technique as a method of waste disposal.

Land farming: This is a method of disposing biodegradable solid waste into farm land where microbial organism can treat them through feeding and converts them to manure. Biodegradable solid waste o be treated are either applied on top of the farm land which has been prepared to receive waste or injected below the surface of the so**il.**

Open dumps: This is the disposal of solid waste in an open space or depression (Nwankwo, 1991). Though very popular and commonly practiced by Nigerians, it is never satisfactory because it poses great hazard to man and his environs through air pollution. Refuse is generally spread over a large area providing a source of food and harborage for rats, flies and other vermin. Too many sites have been used as open dumps with no attention paid to the problem of leaching of the waste resulting in ground water and surface water contamination. Burning of open dumps produces sulphur dioxide with dangerous toxic gas. A field survey conducted by Urban Development Bank of Nigeria (UDBN) in 1977 shows that open dumps are common across Nigeria.

Ocean and sea dumping: This is the disposal of solid waste into rivers, sea and ocean. It is practiced most by people living in riverine and coastal areas like Portharcourt, Lagos States of Nigeria. This method should be avoided because it increases the BOD

and COD level in water, destroying the water quality and denying aquatic organisms available dissolved oxygen in water, thus leading to their death.

Composting: This is the biodegradation of organic portion of the waste by microbial organism. It requires sorting out of the organic portion of the waste either at generation source or at disposal point.

2.11 SOLID WASTE MANAGEMENT IN NIGERIA

Although, increase in population, urbanization, industrialization and economic liberalization leads to increase in solid waste generation, Nigerians attitude to solid waste management has been to throw away once generated anywhere which is discouraging, destroying the virgin land and waters leading to their pollution.

In 1985, during Buhari regime, the Federal Government of Nigeria introduced an initiative, Environmental sanitation (clean-up) which was mandated to be carried out compulsorily every last Saturday of the month. This initiative was good but its implementation generated a major problem in the country.

Thus, in 1988, the Nigeria government established the Federal Environmental Protection Agency (FEPA, 1988) through decree No. 88 of 1988 as amended y decree 1992 and in the 1999 establishment of Federal Ministry of environment which is concerned with the management of various pollution problems resulting from inappropriate management of solid waste generated.

In addition, in1989, the Federal Government through FEPA formulated environmental guidelines, standards, regulations for achieving sustainable development through effluent and solid waste management formulation. FEPA, through their guideline formulated an Environmental Impact Assessment (EIA) decree No. 86 of 1992.

However, solid waste management in Nigeria is still at infancy. The country is becoming a dump site for deposit of solid waste such as refuse and garbage. Portharcourt, Aba, Lagos and Owerri etc contains piles of solid waste dumped at street corners in the

cities. Imported drums of hazardous chemical waste about 8000 drums were dumped in 1988 at koko in Delta state.

The proper management of solid waste in Nigeria has been attributed to be the key of environmental sanitation (Sule, 2001, pg. 85). He emphasized that in recent times, the quality of life in most of the cities of the developing world is being diminished by uncontrolled and poorly managed solid wastes in the urban environment, thus culminating in a serious environmental pollution, most especially in the residential and the commercial districts of the urban area.

Mountains of refuse are common sites in Nigerian cities and towns of which when efforts are being made to dispose of them, the unhealthy work ethics prevalent amongst the people would not allow a thorough job, hence, some wastes are carelessly dumped along the streets. The effects of this indiscriminate dumping and inappropriate means of handling solid waste often lead to an outbreak of diseases.

The recurrent problem of solid waste management in our urban areas has lead to the issue of environmental sanitation gaining popular concern in Nigeria and the outside world so as to bring about a distinction between the volume of solid waste actually generated and the rate at which it is evacuated or disposed or left to accumulate.

To this end, an efficient solid waste management system with associated benefits to both the environment and human health is critical to attaining sustainable development. This is to promote a healthy, safe and cleaner environment where the lives of urban dwellers will be prolonged (Falade, 2000). It is also critical for promoting environmental quality and the enhancement of economic productivity of the people through employment and income generation from waste – wealth (culled from New Nigeria Newspaper, Sunday18th January 2006).

2.12 LIMITATIONS OF SOLID WASTE MANAGEMENT IN NIGERIA

Generally, problems of solid waste management in our urban centers are; collection, storage, transportation and disposal of the waste materials. Akinbami et al (1996) enumerated the following factors as responsible for the inefficient operation of the

existing urban solid waste in Nigeria. These include lack of adequate personnel, problems of institutional relations, poor city structure, inadequate infrastructure and equipment. Nwankwo (1991) is of the opinion that the difficulties of refuse management is caused by the following factors:

(i) absence of standard storage facilities
(ii) poor town planning
(iii) poor handling of vehicles for collection and transfer of wastes as well as
(iv) financial constraints.

The index of measurement regarding the efficiency of waste management is a function of the relationship between the rate of generation and the rate of disposal of wastes (Akinbami et al, 1997, Kill, 1995). This rate in turn depends not only on the size of the staff on hand, but also on the quality and quantity of the equipment available to the sanitation personnel.

2.13 MAPPING TECHNIQUE APPLICATION IN SOLID WASTE MANAGEMENT

A Geographic Information System (GIS) is basically an organized collection of computer hardware, software, geographic data and personal, designed to efficiently capture, store, manipulate, analyze and display all forms of geographically referenced information (ESRI, 1991). GIS acts as a decision support system by facilitating the management, manipulation and analysis of spatial-temporal data. " for example: Iro 2009 applied GIS in mapping Otamiri River water shed in Owerri, Imo state. Olajide 2007 applied GIS in mapping solid waste disposal point in Obgoshomo North Local Government, Oyo State. Awosan 2006 applied GIS in mapping solid waste collection point in Ajoda New Town, Ibadan". GIs applications are dimensionless ranging from micro level to macro level planning (Burroughs, 1986 and Nnabugwu, 2007). However, the boundless capabilities are limited by ones ability to visualize its implications. GIS is used extensively in government business and research for a wide range of applications including environmental resource analysis, land use planning, location analysis, tax appraisal, utility and infrastructure planning, real estate analysis, marketing and

demographic analysis, location analysis or site selection, water quality management, agriculture and forest managements, etc (Mather, 1991, Nnabugwu, 2003 and Olajide, 2007).

Kufoniyi, (1998) stressed that the solution of environmental problem relies on the use of appropriate tool for managing urban areas. Hence, GIs becomes the efficient tool for suck task. He further stated that a well designed GIS has capability of providing new flexible form of output such as customized maps, quick and easy access to large volume of data, the ability to merge one dataset with another and the means to analyze spatial characteristics of data.

Jeffery and John (1989) reported that “Site selection using a GIS” is a classical case of land capability analysis. Since, solid waste generation is a land-based activity, hence, proper analysis, visualization and mapping of the volume, frequency, variety and distribution of solid waste generation is best handled with GIS technology.

Njoku (2010), stated that spatial decision making problems such as site selection requires the consideration of multiple and conflicting criteria and objectives, therefore a solution method that contributes towards consensus building is required, supporting decision making in a spatial context is the implication in the use of GIS.

A land suitability modeling can be presented using environmental, economic and other location criteria through the use of a GIS. Selection of suitable sites for a research center according to ESRI (1996) identified the following techniques;

- Preparing data for analysis
- Creating buffer zones
- Using boundary operations
- Performing polygon overlay
- Manipulating tabular data
- displaying spatially referenced data.

From the foregoing review, GIS is observed to be an efficient tool for land suitability analysis selection. It has the capability of accepting data from diverse source integrating them with other useful in formations and performing query and carry out spatial analysis. Thus, with these capabilities, this study intends to exploit GIS in mapping out solid waste collection and disposal points in new Owerri.

CHATER THREE

RESEARCH METHODOLOGY

3.1 DATABASE DESIGN

Database design otherwise known as data modeling is the process of defining features to be included in the database, their attributes and relationships, and their internal representation. Database is the core or heart of any GIS operations. It allows system to meet up with the information or needs of the people (purpose) for which a GIS project is carried out.

Kufoniyi (1998) defined database design as the process by which real word entities, their attributes and relationships are analysed and modeled in such a way that maximum benefits are derived using the minimum sets of data. Database design passes through the following phases;

(i) Conceptualization design (ii) Logical design and

(iii) Physical design.

Below is the diagram showing the phases of database design.

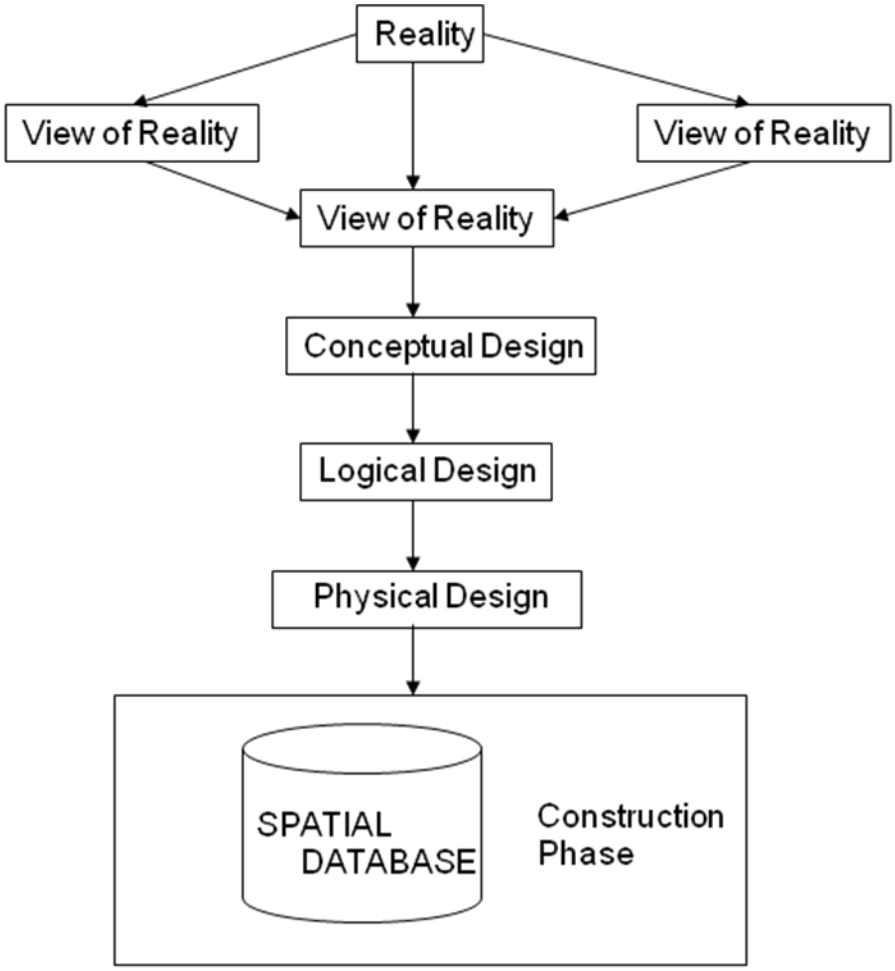

Fig 3.1 Design and construction phases of a spatial database (Kufoniyi, 1998)

3.1.1 View of reality

View of reality is the mental abstraction of reality for a particular relevance to the application or group application at hand. It is simply the perception of reality as they actually existed. E.g. the roads, rivers and land uses are seen on the study area as they actually existed. View of reality forms the bases of which observed features are represented in the stages of data modeling.

3.1.2 Conceptualisation of reality

This is also called external view. It is concerned with the way in which the data is viewed by end users (individual perception of reality). At this stage of the database design, decisions are made on how the view of reality will be represented in a simplified manner and still satisfy the information requirement of the user. Conceptual design is a concise describes the data types, relationships and constraints expressed using the concepts provided by the high level data model. The objective however is to determine the basic entities, the spatial relationships between them and their attributes and how they will be modeled in such a way as to satisfy desired need.

In this project, the vector model was adopted for use as Linear (1 – D), area (2 – D) objects depending on the features geometric structure). The location of objects in the data are given as X and Y coordinates, they are adopted for use and their represented relatives were treated as points, lines and polygon feature class. The entities or layers generated in this project were;

- Land use layer (polygon)
- Road layer (line)
- River layer (line) and
- Ward boundary layer (polygon)

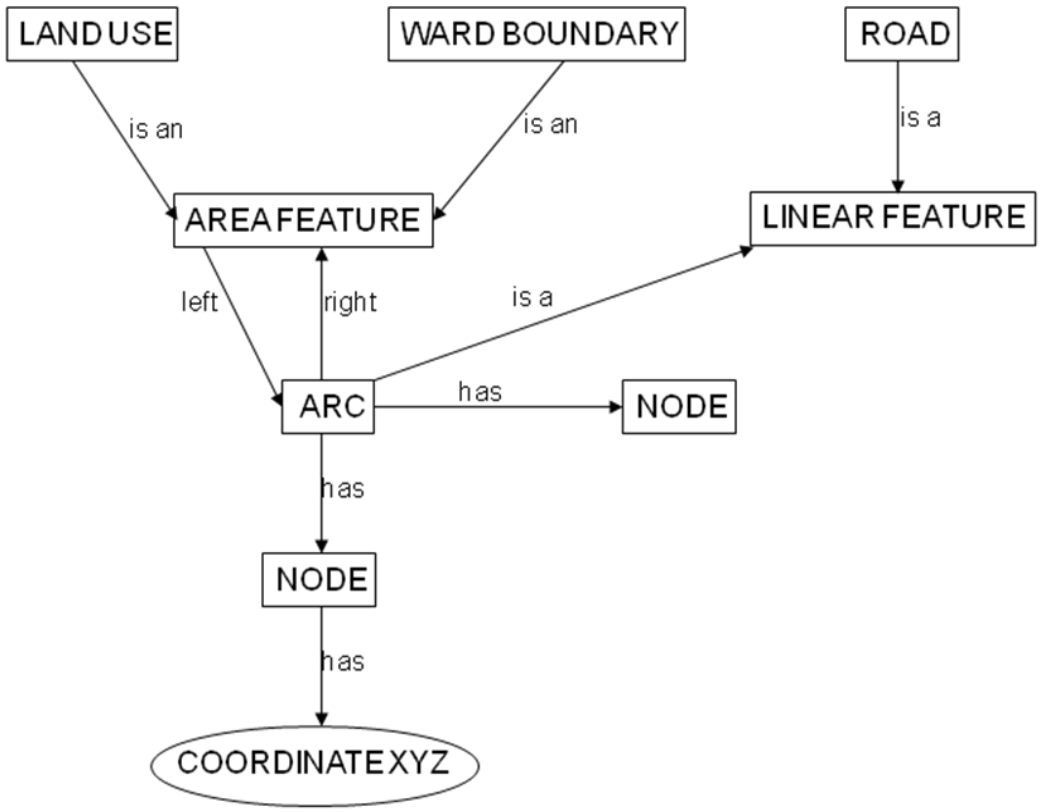

Fig 3.2 An Entity Relationship Diagram representing the spatial data structure for vector maps (Moleenar, 1995)

As used in Fig. 3.2, the term area feature is used to describe a homogenous extent of the earth bounded by one or more features, such as land use. A linear feature is a geographic feature that can be represented by a line or set of lines such as road or river. Area and Linear features are represented by arcs. In the same vein an arc is an ordered string of vertices that begin at one location and end at another, connected by line. The vertices at each end point of an arc are called nodes, which are the beginning and ending locations of an arc.

3.1.3 Logical design

Logical design otherwise called data structure describes how entities and their attributes are represented or simply the recording pattern of data in computer system.

The conceptual data model in Fig. 3.2 was translated into a relational logical design data structure as below;

Table 3.1 logical design of data structure

entity	Attribute field				
Road	Rd-id	Rd-type	Rd-name	Rd-length	
Boundary	Bndry-id	Bndry-name	Bndry-area		
Land use	Ld-id	Ld-type	Ld-status	Ld-area	Ld-pop dsty
River	Rv-id	Rv-name	Rv-length		

3.1.4 Physical design

This is an implementation stage in which the internal data structure and organization for the database were specified. It is also referred to as a high-level representation of data sets and the representation is guided by well spelt-out constraints. At this stage, the field name, data types and width are specified. The representation of features is determined by the type of software used. Arcview 3.2a software used in this project represented lines, point object and areas as polygons.

Table 3.2 physical design showing attribute table of land use map

Table Name	Attribute	Description	Data Type	Data Width
Road	Rd-id	Road unique identifier	Numeric	3
	Rd-type	Road type	String	9
	Rd-length	Road length in meters	Numeric	8
	Rd-name	Road name	String	30

Boundary	Bndry-id	Boundary identifier	Numeric	1
	Bndry-name	Boundary name		
	Bndry-area	Boundary area in hectares and square meters	String	30
			Numeric	8
Land use	Ld-id	Land use identifier	Numeric	3
	Ld-type	Land use type	String	30
	Ld-status	Land use status	String	25
	Ld- pop dsty	Land use population density	string	15
River	Rv-id	River unique identifier	Numeric	1
	Rv-length	River length	Numeric	8
	Rv-name	River name	string	20

3.2 DATA ACQUISITION

The main data required for this project are land related data such as maps, coordinate values, name and length of roads, status of land uses, etc.

3.2.1 Data source

Generally, there are two types of data namely; primary and secondary data. The data source for this project relies mainly on secondary data; they are Owerri Street Guide map and Owerri master plan collected from state ministry of land and survey, new secretariat, Owerri. This contains the land use data at a scale of 1: 20,000, layout maps of New Owerri, map of Imo state showing Owerri municipal area and Owerri west area. Other secondary sources includes documented materials such as magazines, newspapers, libraries, written texts, related journals, maps and satellite imagery of the study area gotten from Google Earth in the internet.

Also, a form of obtaining first hand information from the study area otherwise called primary data obtained include the Geographical coordinates of three points using Google earth software, the name of the areas and streets, the length of roads as well as a ground thruthing field observation embarked upon to confirm the features on the maps.

3.2.2 Data conversion

The maps used in this project were in analogue format. They were however converted into digital format through the process of vectorization (scanning with scanner and georeferencing and digitizing with auto cad software). The digitization of the map produced the following layers;

(i) Land use (ii) Road and (iii) River.

3.2.3 Geometric data acquisition

Geometric data were acquired through the use of Google earth software from internet to supply the coordinate values of points in the study area (in geodetic format). The geographical co-ordinates were converted to rectangular (using the Geo-calc software) which is the acceptable referencing system for geo-referencing maps in the AutoCAD software.

The coordinate points are as follows:-

(i) First reference point (Assumpta Cathedral Owerri)

N 05^0 29’ 18.97”

E 07^0 01’ 15.36”

(ii) Second reference point (Imo Concorde Hotel)

N 05^0 28’ 21.67”

E 07^0 01’ 10.69”

(iii) Third reference point (junction between NMT1 and WMT2 Highway along Umuguma)

N 05^0 28’ 46.63”

E 06^0 59’ 51.85”

3.2.3.1 Georeferencing

This is the process of bringing the scanned map into its true earth (location) coordinate on the computer system using an acceptable referencing system. The Universal Traverse Mercator (UTM) with referencing to Mina datum was used. The geographical co-ordinates obtained with Google Earth software were converted to rectangular (using the Geo-calc software) which is the acceptable referencing system for geo-referencing maps in the AutoCAD software. Thus, each image was corrected for scale and station and geo-referenced using the following converted coordinate points.

i) First reference point (Assumpta Cathedral) East

X 2 80735.310 E

Y 6 0 6980.746 N

ii) Second reference point (Imo Concorde Hotel) South

X 280585.719 E

Y 605220.910 N

iii) Third reference point (junction between NMT1 and WMT2 Arterial Highway along Umuguma) West

X 278160.896 E

Y605995.765 N

3.2.3.2 Digitizing

This is the systematic extraction of important features from the map to be used in GIS spatial analysis. The features on the map were digitized as points, lines and polygons and were classified into themes for proper identification, differentiation, thematic map creation and other analytical operations. The onscreen digitizing was done with the use of AutoCAD Land Development 2i where the map was digitized into the following layers;

(i) Land use - Commercial

- Residential

- Public (including recreational, administrative, reserve and religious land uses)

(ii) Road (iii) River and (iv) Boundary layers.

3.2.4 Attribute data acquisition

The attribute data were collected through primary and secondary data sources. They are for residential, commercial and public use land uses, roads, river and boundary. "The attribute tables for the various land use types mentioned above are shown on appendix ii below"

Thus, in the process of carrying out the project, the following operations were performed for efficient and effective actualization of this plan;

- Procurement of digital map of new Owerri from internet and coordinate points with the aid of Google Earth software which is to be combined with analogue maps of the same area gotten from Ministry of Land and Survey and Owerri Capital Development Authority (OCDA), all from Imo State.

- Conversion of procured geodetic (geographic) angle from Google Earth software to Rectangular (projections) coordinates with the aid of Geocalculator software for georeferencing in AutoCAD.

- Conversion of analogue map to digital map followed by georeferencing and digitization in AutoCAD which is exported into Arcview software.
- Design and creation of database that will support the integration of record of land use, rivers and road network of the area, which will permit updating and retrieval of information pertaining to the study area.
- Collection and structuring of the attribute data using Arcview 3.2a software.
- Performing analysis using Arcview 3.2a software.

3.3 SYSTEM DESIGN

3.3.1 Hardware requirement

A hp pavilion v4225nr personal computer (laptop) was used with the following configurations;

- Intel ® Celeron (PM) CPU, rated at 3.2 window experience index (named Xp window 7), manufactured at Haiter,
- 5.12MB of RAM of 32-biting operating system type,
- A mustak Az Scanner
- A HP DeskJet D1560 Printer

3.3.2 Software requirements

The following software was used for this project;

- Microsoft Window XP Professional window 7 viena, Service pack 3, version2008-2009.
- Arc View GIS Version 3.2a for spatial analysis of site selection.

- AUTOCAD Land Development 2i for georeferecing and digitizing the scanned map
- GEO CALC (Geographic Calculator 3.09) Software for conversion of coordinates from geographical to rectangular and vice – verse.
- Google Earth Software for acquiring satellite imageries and geographical coordinates.

3.4 DATABASE CREATION

This is the construction phase of obtaining GIS database after three levels of design phase. It involved the organization of the data in the forms that were compatible with the relevant software. The analogue map digitized in AutoCAD was exported to Arc View where area features were polygonized. Both acquired spatial and attribute data were used in creating the database. The process went thus;

Launch Arc View 3.2a, click “Open theme”, icon table was displayed. Click “edit menu”, select “start editing”, select “add field”. A dialogue box was displayed. Input name, i.e. land use area, land use type, land use status etc., input data type i.e. string, number or Boolean as appropriate then click “edit menu”. Select “add record” and type in the entire attribute in the table and click “edit menu” and finally “stop editing”.

3.5 DATABASE MAINTENANCE

This is an aspect of database management system concerned with the maintenance of data to retain its value. It involves management of quality, integrity and security aspect of the database.

3.5.1 Data quality

This is the application of quality assurance and quality control measures while carrying out the project to ensure high confidence limit in the guaranteeing of the work. The measures include;

- The hard copy map was obtained from the state ministry of land and survey, new secretariat, Owerri, Imo State.
- The georeference points (coordinates) were collected directly from internet with Google Earth software etc.

3.5.2 Data security

Security measures adopted in this project includes;

- Data were properly protected in the system with the use of password codes,
- Backups were put in place to protect the data from being lost as well as devices being used,
- Data transfer and transaction were done with utmost care.

3.5.3 Data integrity

This ensures the consistency and correctness of data stored in a database, the data integrity adopted for this project is the domain integrity were the data type, width and decimal of attribute were all specified.

CHAPTER FOUR

SPATIAL ANALYSIS, DISCUSSION AND RESULT PRESENTATION.

4.1 INTRODUCTION

Spatial analyses are the operations performed on spatial data to find solutions to spatial problems. It involves the organization of database into layers for the purpose of providing rapid access to the data that might be required for geographic analysis. By applying the abstraction process, real world entities were stimulated into the computer. The process involved;

(i) Identifying the spatial feature form the real world that are of interest in the context of an application and choosing how to represent them in the conceptual model.

(ii) Representing the conceptual model by an appropriate spatial data model.

(iii) Selecting an appropriate spatial data structure to store the model within the computer.

For this research work, spatial analyses were performed to locate the best locations for solid waste collection within New Owerri in Owerri, Imo State. Investigation from local authority and field survey revealed that there were no standard criteria for ascertaining and zoning of solid waste collection points in Imo State. For this reason, the user-based criteria based on the United Nations (UN) standard criteria requirement was adopted for this research work.

The spatial operations used in the spatial analysis include buffering, overlay (union), clipping and querying of data to arrive at the needed goal, the entities of interest, (i.e. Roads, rivers and other land uses) were buffered. The buffering cut across the study area at 100meters away from the features of interest at a distance 10meters per-ring, generating 10 rings on around the feature. This was done to take care of the situation at hand as well as future expansions.

4.2 CRITERIA FOR SELECTING SUTIABLE SOLID WASTE COLLECTION POINTS

In selection of solid waste collection points, the following selection criteria set based on the United Nations Standard Criteria Requirement was adopted. They are;

- The collection point should be 10m away from roads (for easy collection and to prevent road blockage).
- The collection point should not be less than 70m away from water bodies e.g. rivers.
- They should be 40m away from public use areas
- They should be 20m away from commercial areas.
- They should be 20m away from residential areas (thus within the proximity of prospective users).
- A collection point must be at least 200m away from one another.
- The population density must determine the number of collection points within each layout.
- It must be along the road/street junctions

(Source: www.gisdevelopment.net)

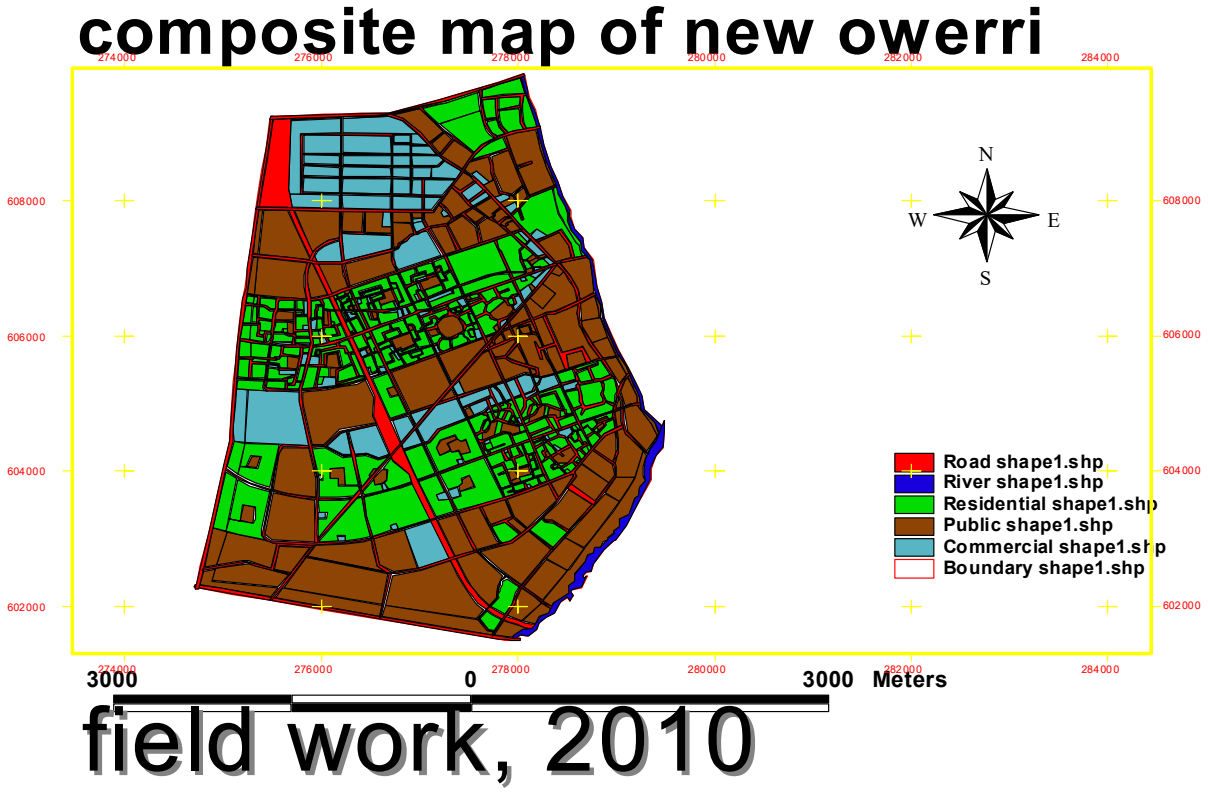

Fig 4.1 layout of composite map of the study area (New Owerri)

4.3 CARTOGRAPHIC MODELLING

A cartographic model is a set of interacting, ordered map operation that act on raw data as well as a derived and intermediate map data to stimulate a spatial decision making process (Michael, 1997). It is simply a graphical representation of data and analytical procedures employed in building up a spatial database. It is also the process of linking or organizing basic analysis operations in a logical sequence such that the output from one is the input to the next. In this project, the cartographic model revealed the step by step procedures of combining declared data (themes) to generate the product i.e. the most suitable sites.

One unique aspect of GIS is its capabilities of carrying out analysis on real word data, it allows for analysis of an existing database on geographic relationships. GIS analysis used in this project includes buffering, overlay operations (unioning), clipping and spatial queries. These operations were carried out to analyze all the established criteria necessary for the location of solid waste collection points.

(i) Buffering of roads, rivers, residential, commercial and public use land uses (buffer of 100m at an interval of 10m).

(ii) Union of buffered results

(iii) Clipping of unioned results with boundary

(v) Single and multi-criteria queries.

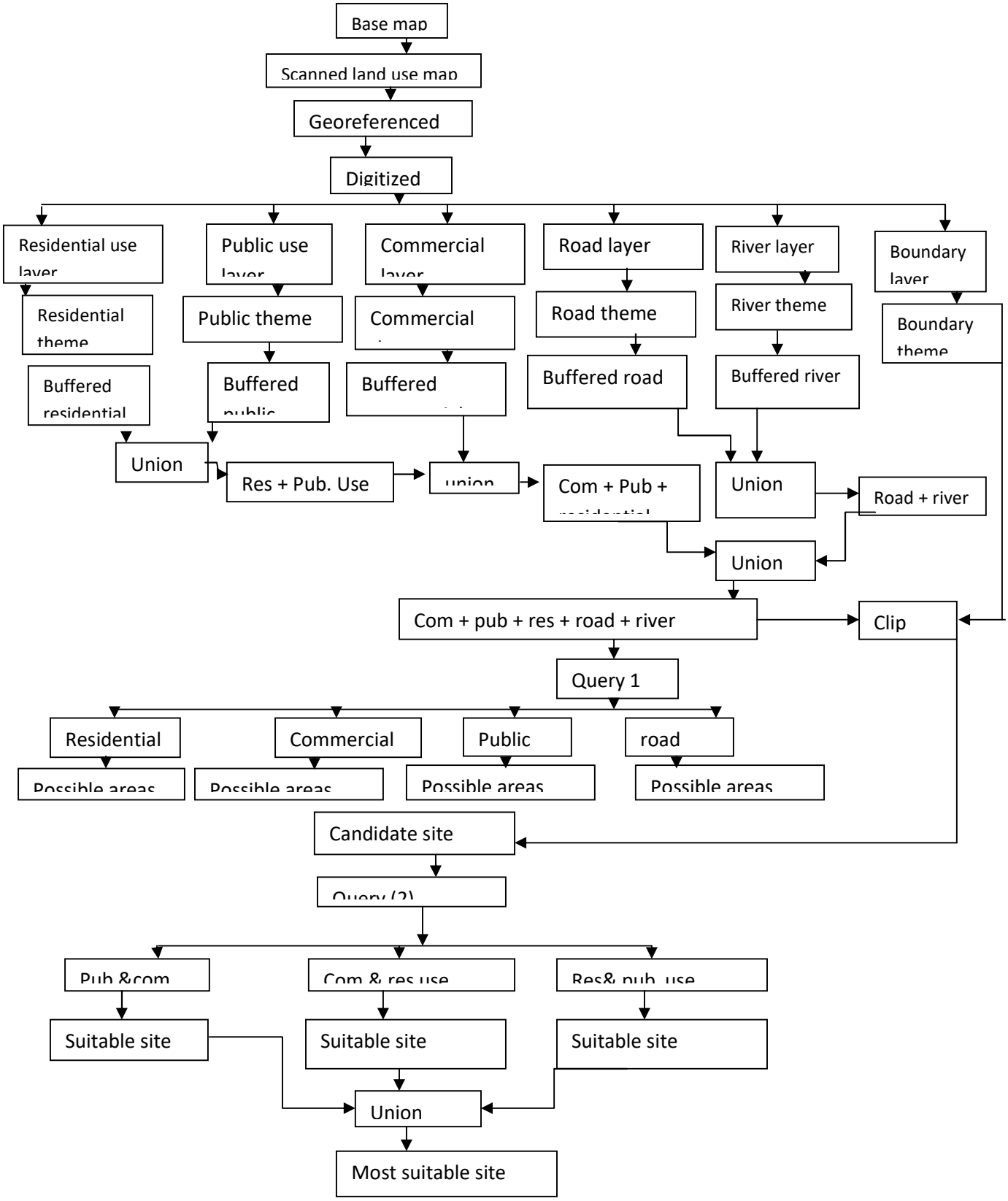

Fig 4.2 Cartographic model of this study

4.4 SPATIAL ANALYSES PERFORMED

4.4.1 Digital mapping processes on map of new owerri

Owerri street guide map was scanned and imported into the AutoCAD land development software where it was georeferenced and digitized. Arcview GIS 3.2a was launched and the digitized map was exported from Auto CAD to Arc view. The road, boundary, rivers, residential, public and commercial layers were converted to shape files after which the various entities were polygonized with Arcview script. Thus, all the features were converted from polylines to polygons which are the acceptable shapes for spatial analysis in the Arcview environment.

Fig 4.3 to 4.5 shows respectively the scanned georeference new Owerri map in Autocad environment, digitized map of new Owerri in Autocad environment and shapefile of new Owerri in Arcview 3.2a software.

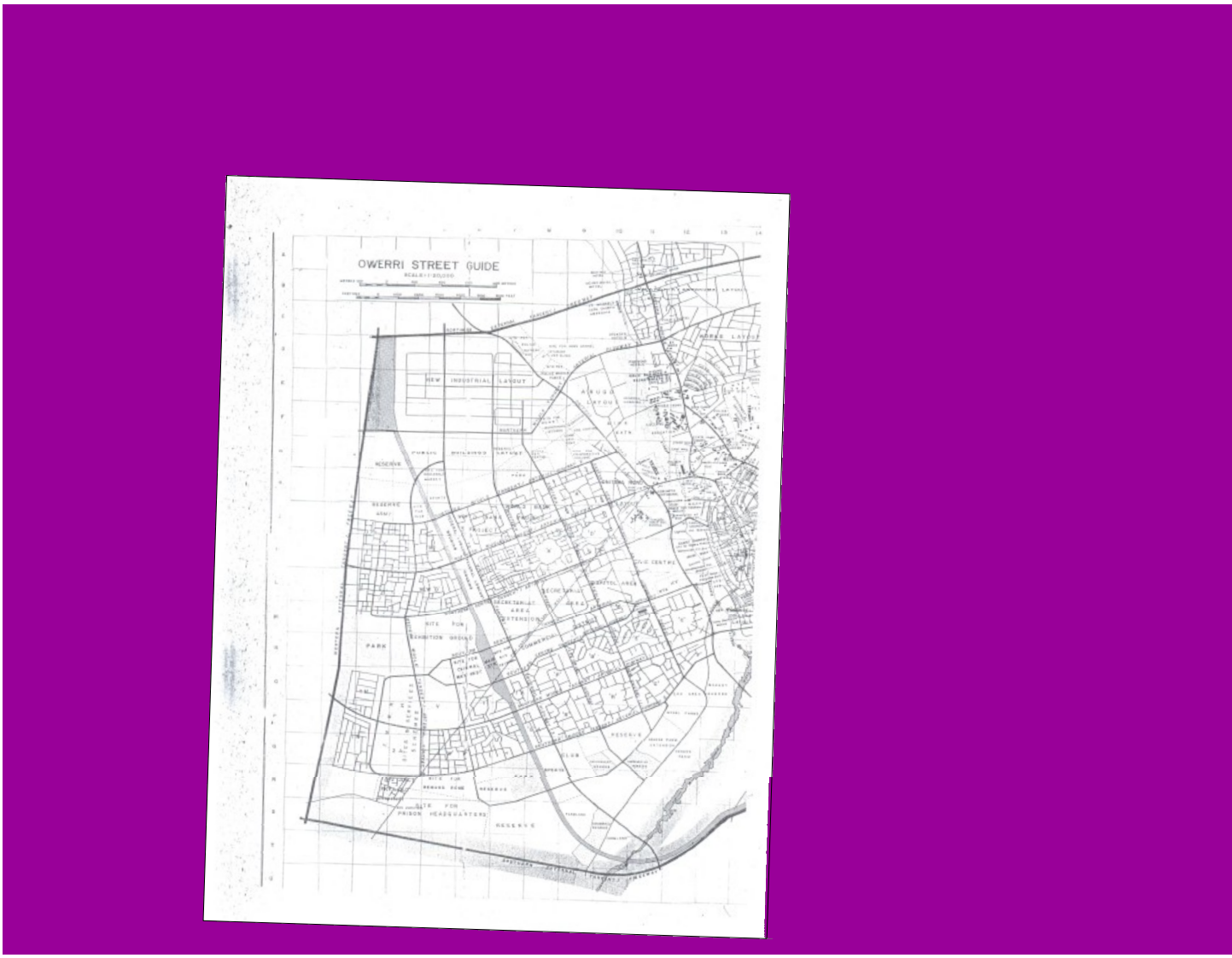

Fig4.3 Georeferenced New Owerri map in an AutoCAD environment

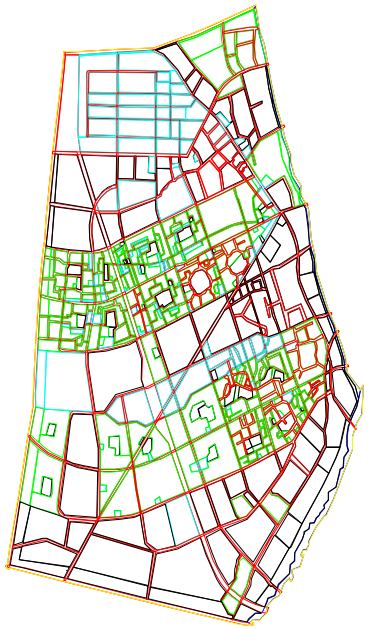

Fig 4.4 Digitized map of new Owerri in an AutoCAD environment

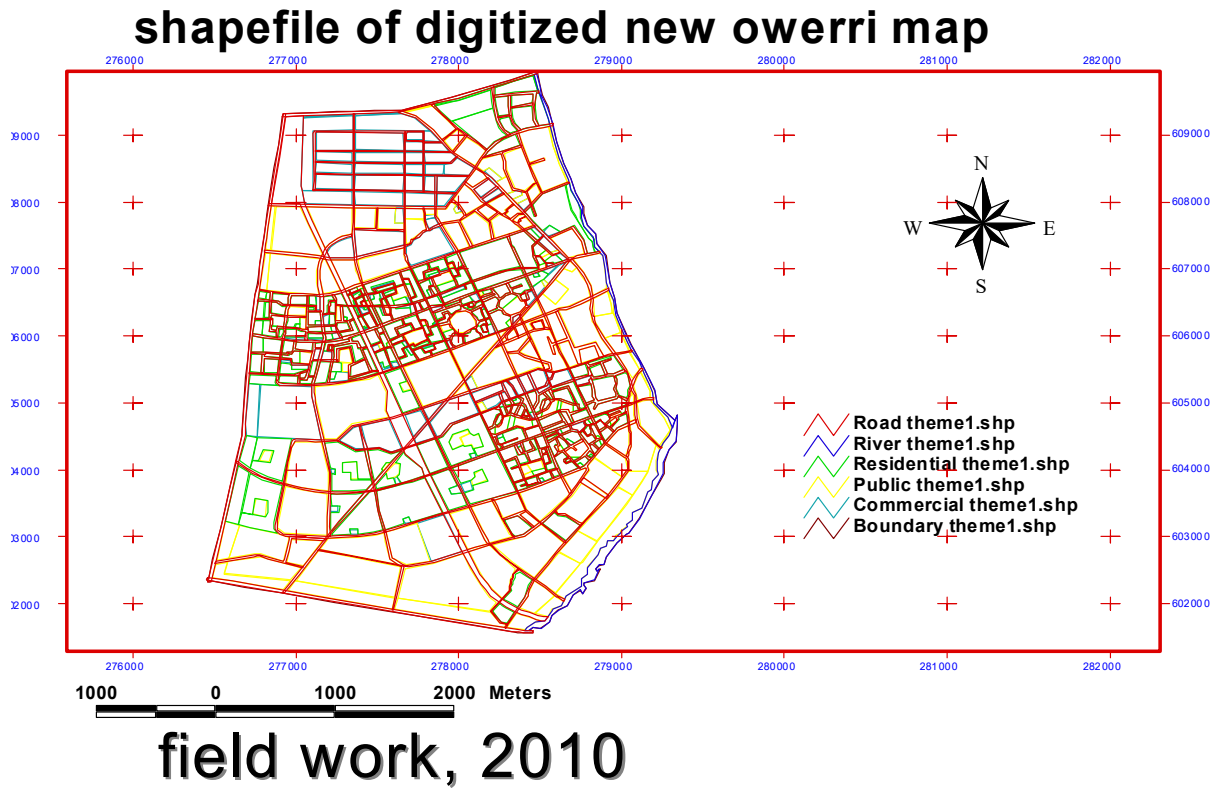

Fig 4.5 layout of shapefile of imported digitized map of new Owerri in Arcview 3.2a

4.4.2 BUFFERING OPERATION

One important spatial operation is the determination of spatial proximity or nearness of various geographic features. The operation performed by the buffer command generates one or more polygons surrounding geographic features and the polygon is called BUFFER ZONE. In this study, buffering operation of 100m at an interval of 10m was carried out on all the entities.

4.4.2.1 Analysis of buffering operation

Make the theme (feature) to be buffered e.g. river theme active click the 'theme' menu on the toll bar and select 'create buffe'. A dialogue box is shown. Click 'next' and select

‘as multiple rings’ then input the number of rings, distance between rings and units. Click next and on the new dialogue box, click on ‘yes’ for dissolve barriers between buffers?’ Also select ‘only outside the polygon’, then save in a new theme and click finish. The new theme will definitely show.

Fig 4.6 to Fig 4.9 show all the buffering operations performed.

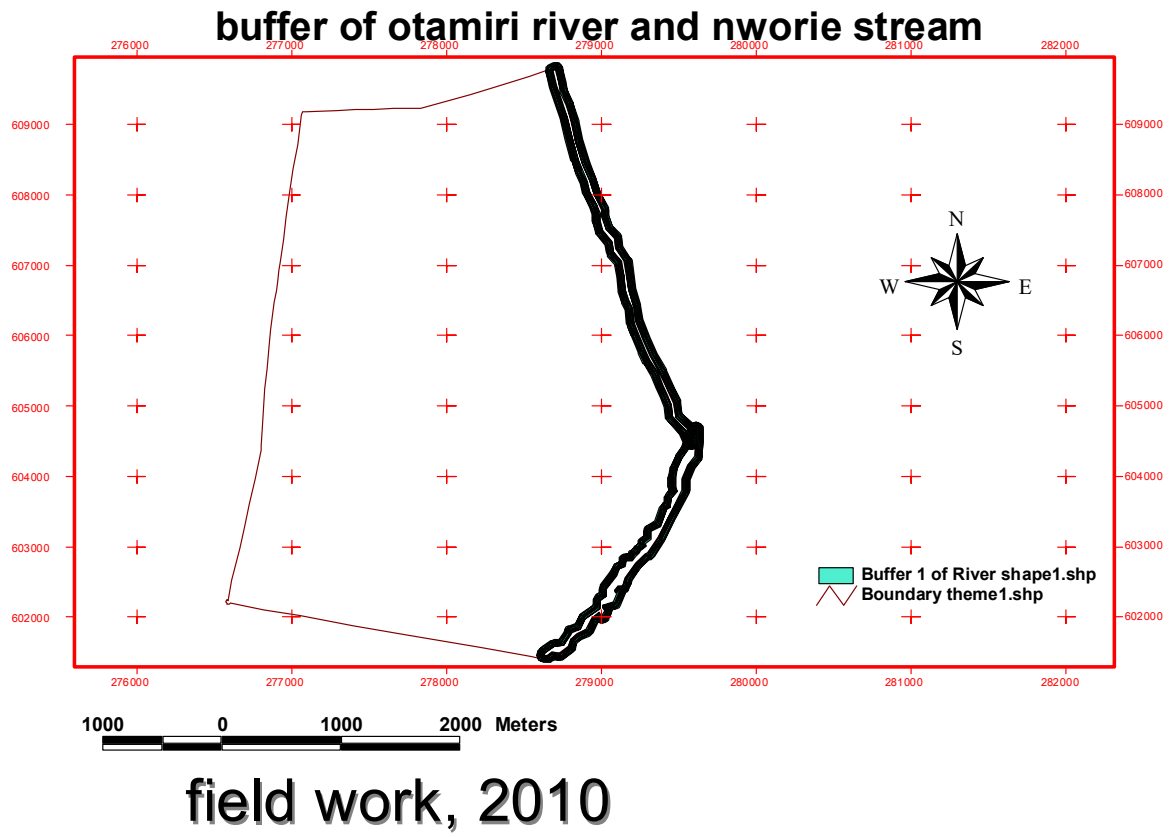

Fig 4.6 layout of the buffer of otamiri river and nworie stream

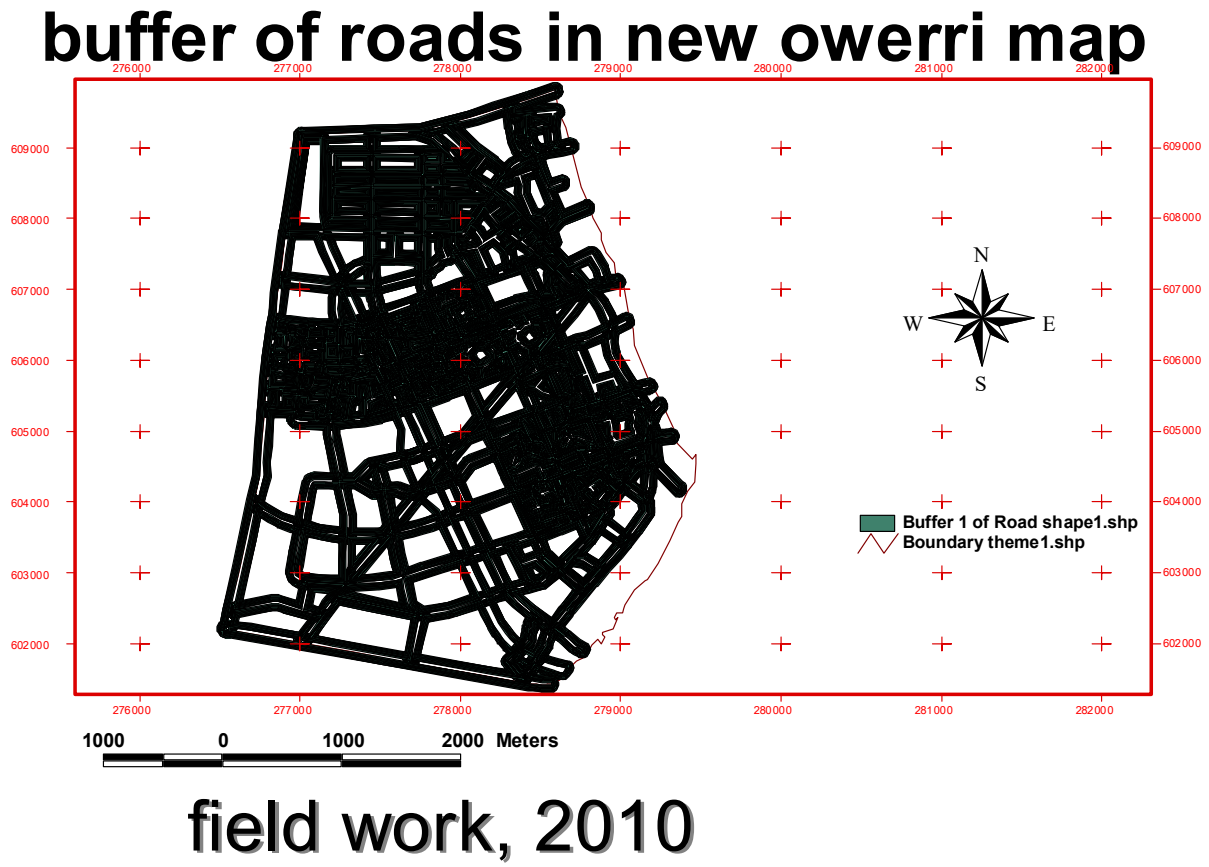

Fig 4.7 layout the buffer of roads in New Owerri area

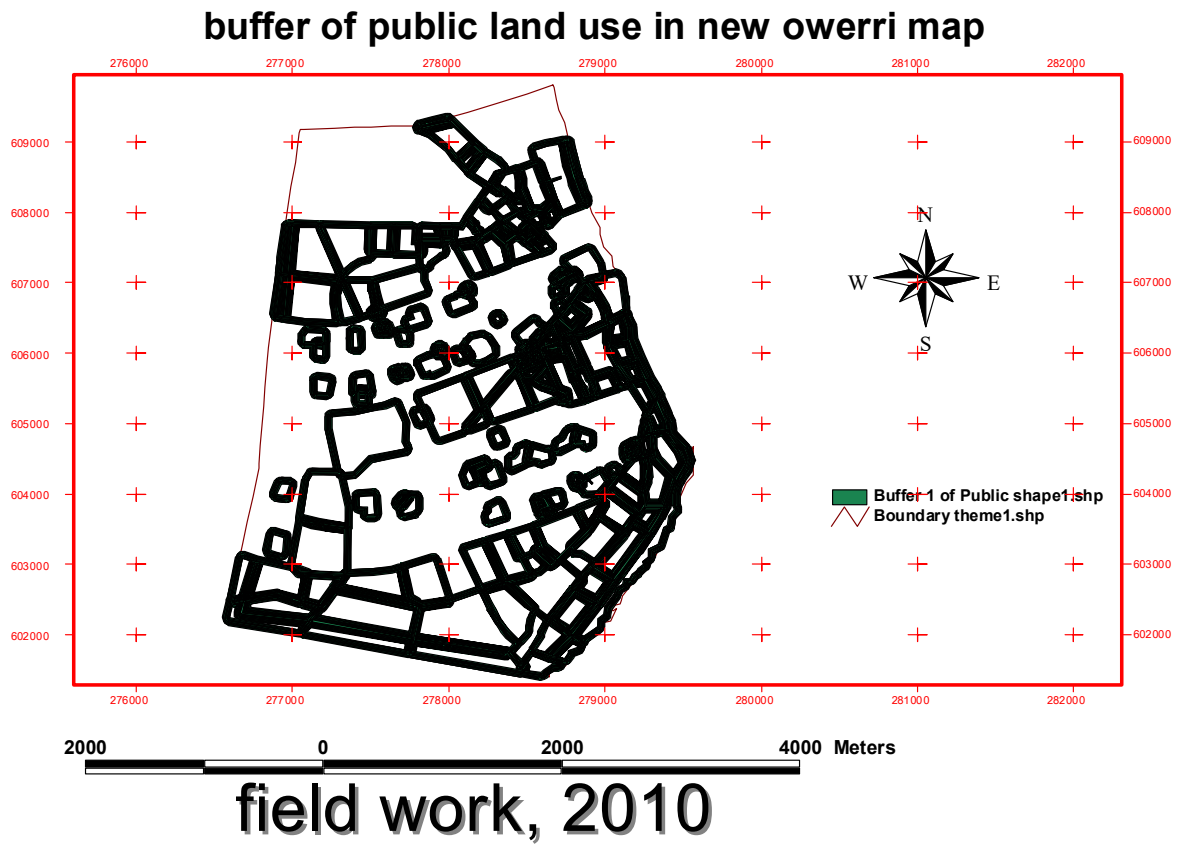

Fig 4.8 layout of the buffer of public use theme in New Owerri

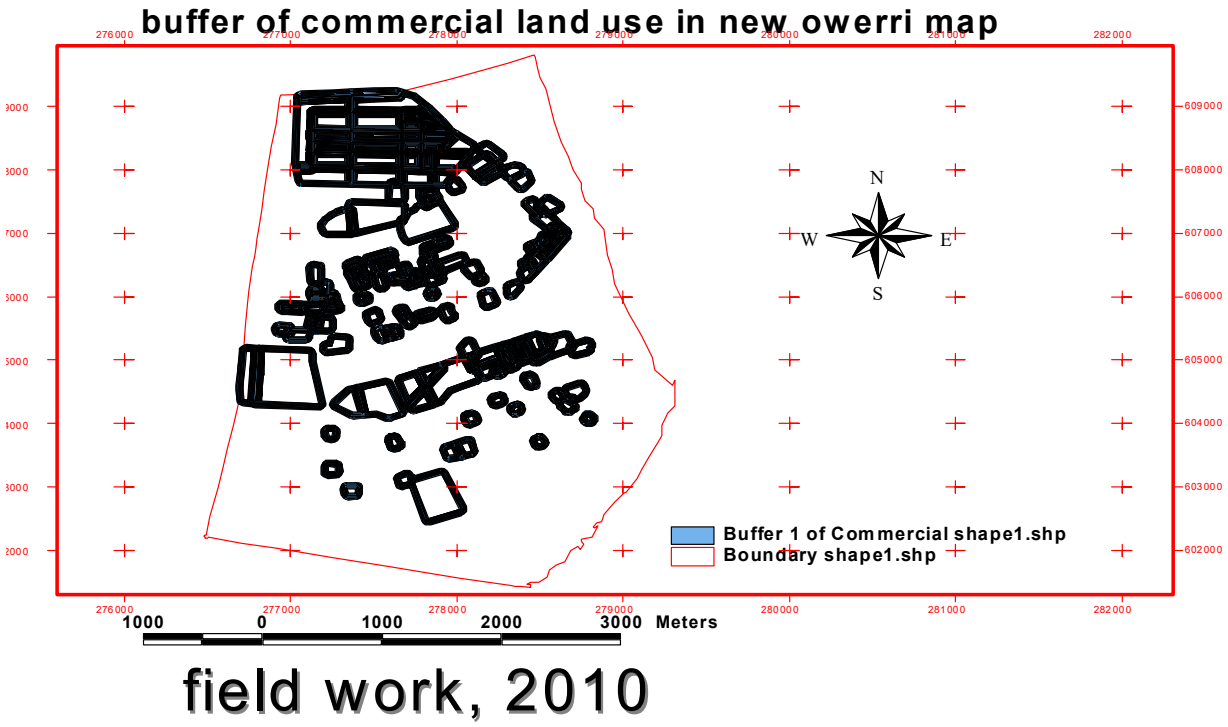

Fig 4.9 layout of the buffer of commercial land use in New Owerri

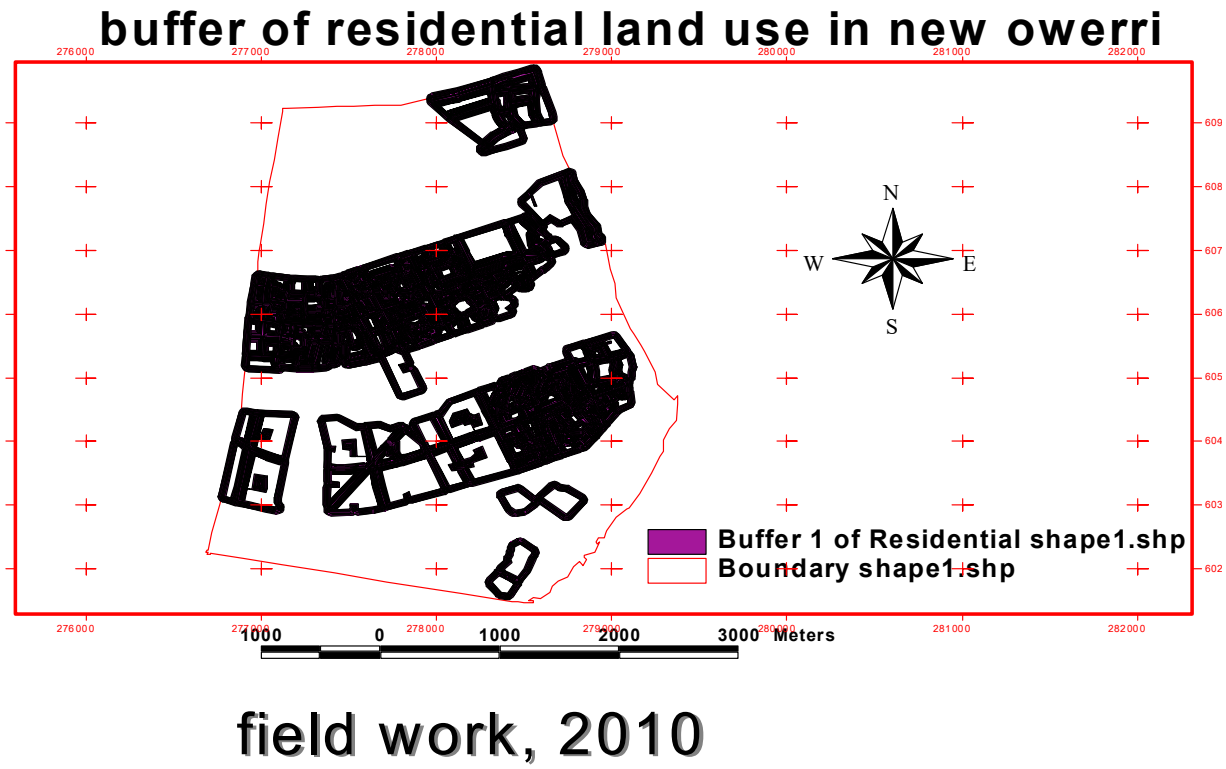

Fig4.10 layout of the buffer of residential land use in New Owerri

4.4.3 Overlay operations

This is a GIS analytical tool used to merge two themes representing different data sets to generate a new set of information. Topological overlay can be used for different objectives such as theme updating, feature extracting, merging adjacent themes and merging feature attributes.

The concept of overlay is by combining two or more themes (features), usually in preparation for further analysis. For this research, overlay by union of entities was applied. Overlay by union is used to combine features of an input theme with the polygons from an overlay theme, to produce an output theme that contains the attributes and full extent of both themes.

For this project, the following overlay operations were performed;

(i) First Overlay: The buffered residential land use theme was overlaid (unioned) with the buffered public use land use theme to have another output theme called union of residential and public use land uses.

(ii) Second Overlay: The buffered commercial theme was overlaid with union of residential and public use theme to produce a new output theme called; union of commercial, public use and residential land uses.

(iii) Third overlay: The buffered road theme was overlaid (unioned) with the buffered river theme to have another output theme called union of road and river.

(iii) Fourth overlay: The unioned road and river were overlaid with the union of commercial, public use and residential land uses, to produce a new output theme called; final union made up of the union of commercial, public use, residential, river and roads theme.

4.4.3.1 Analysis of overlay operation

Click on ‘view’ on the tool bar menu and select ‘geo processing wizard’. A dialogue box is shown; select ‘union two themes’ and click next on the new dialogue box, specify the two themes involved e.g. buffer of commercial layer and buffer of public use layer. Specify the output file and click ‘finish’. The new theme will definitely show.

Fig 4.11 to Fig 4.14 show all the overlay by union operations performed.

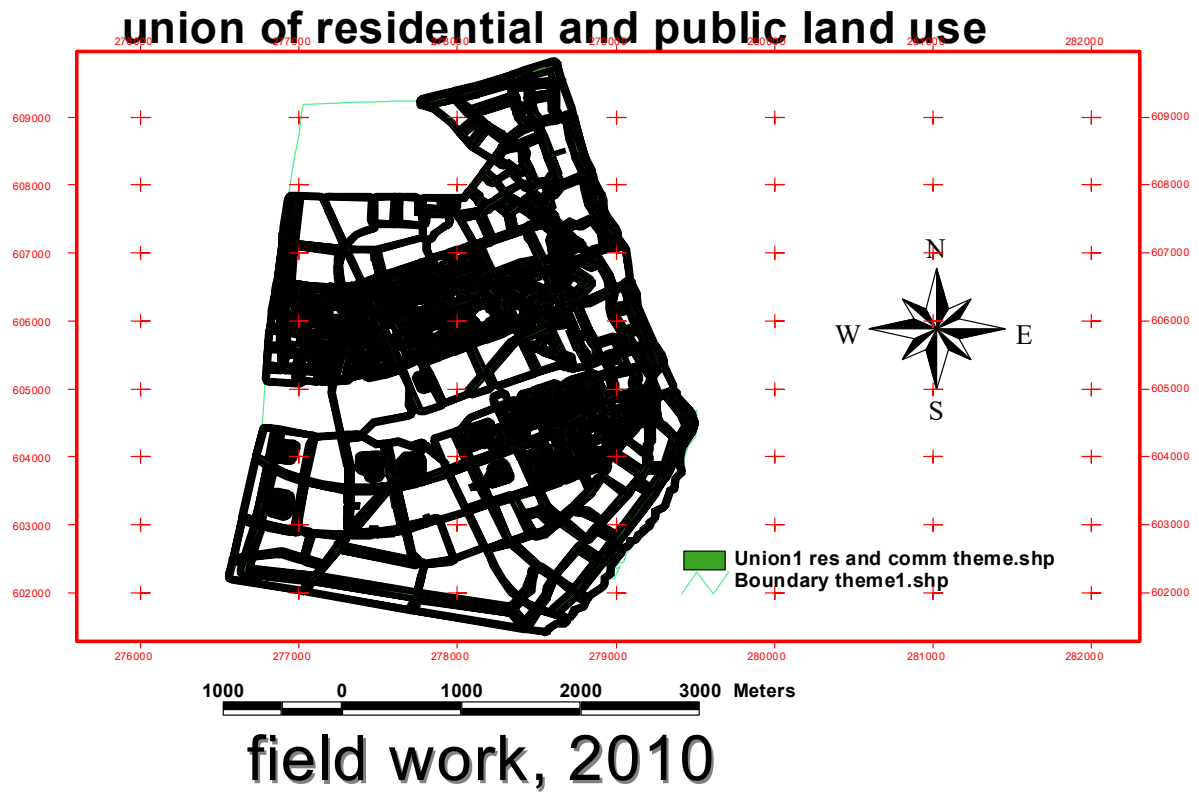

Fig 4.11 layout of the union of residential and public land use

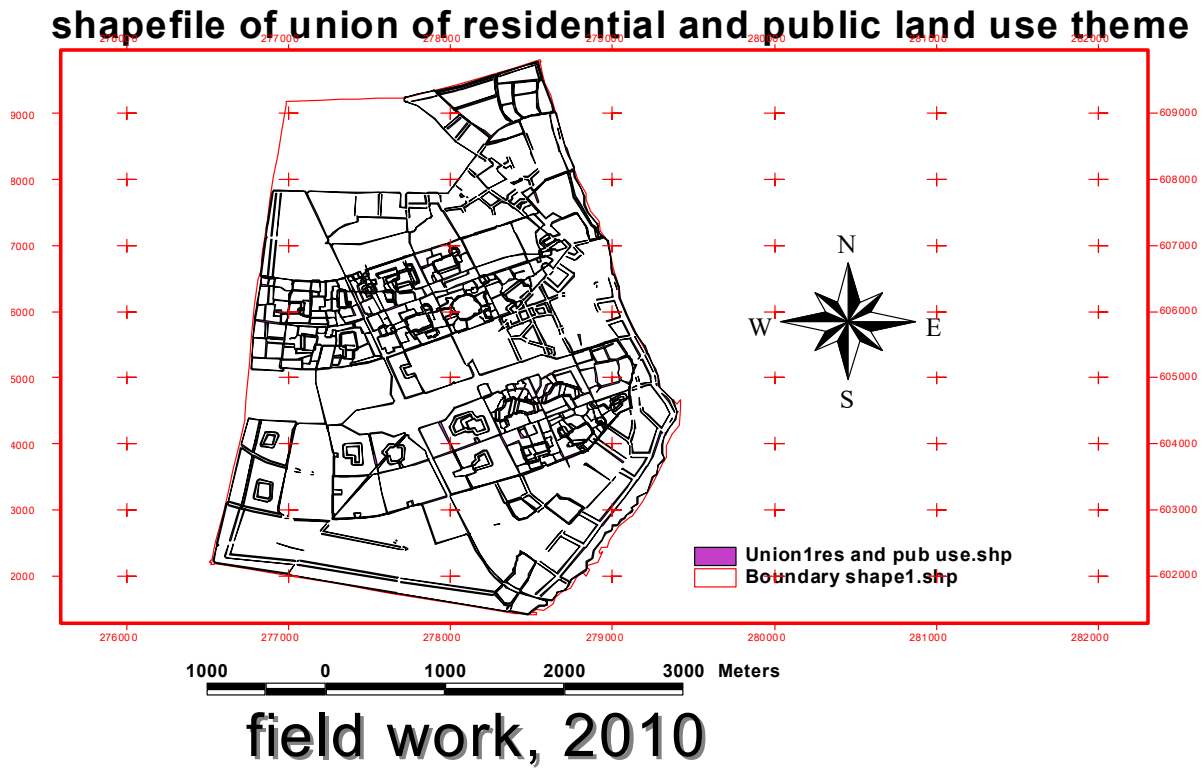

Fig 4.11.a layout of shapefile of the union of residential and public use theme

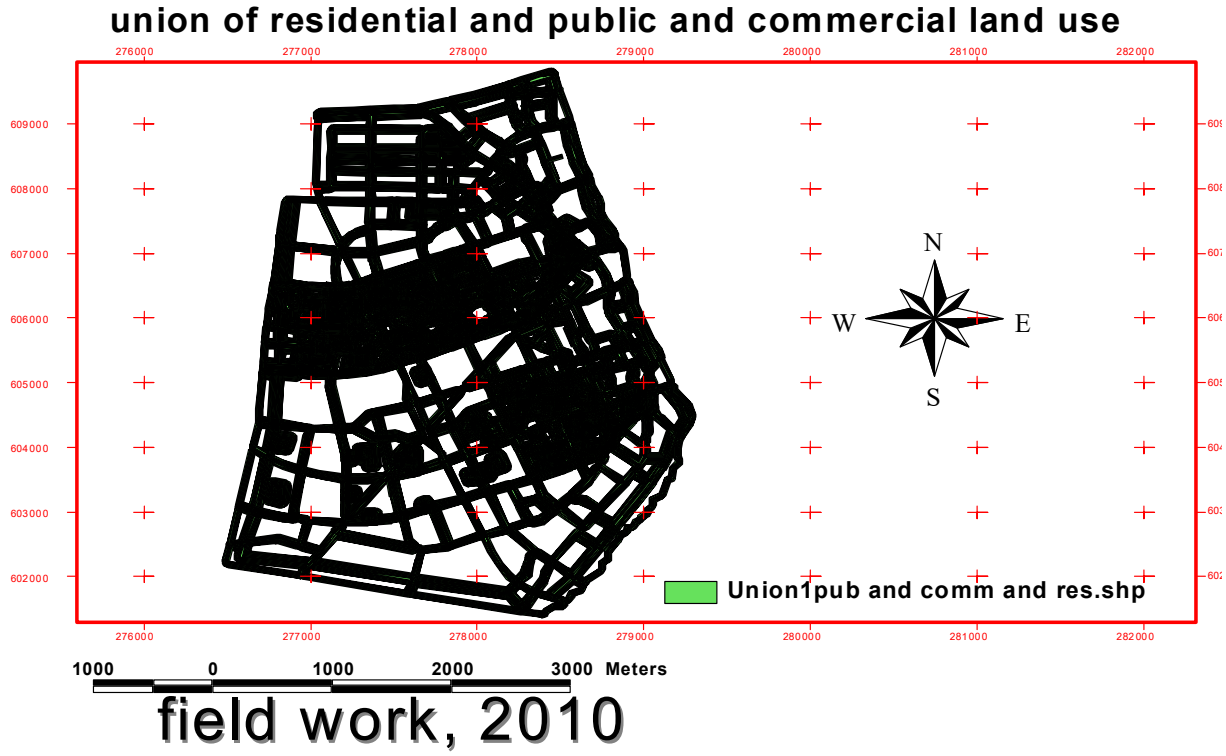

Fig 4.12 Layout of union of buffered commercial, public use and residential land uses

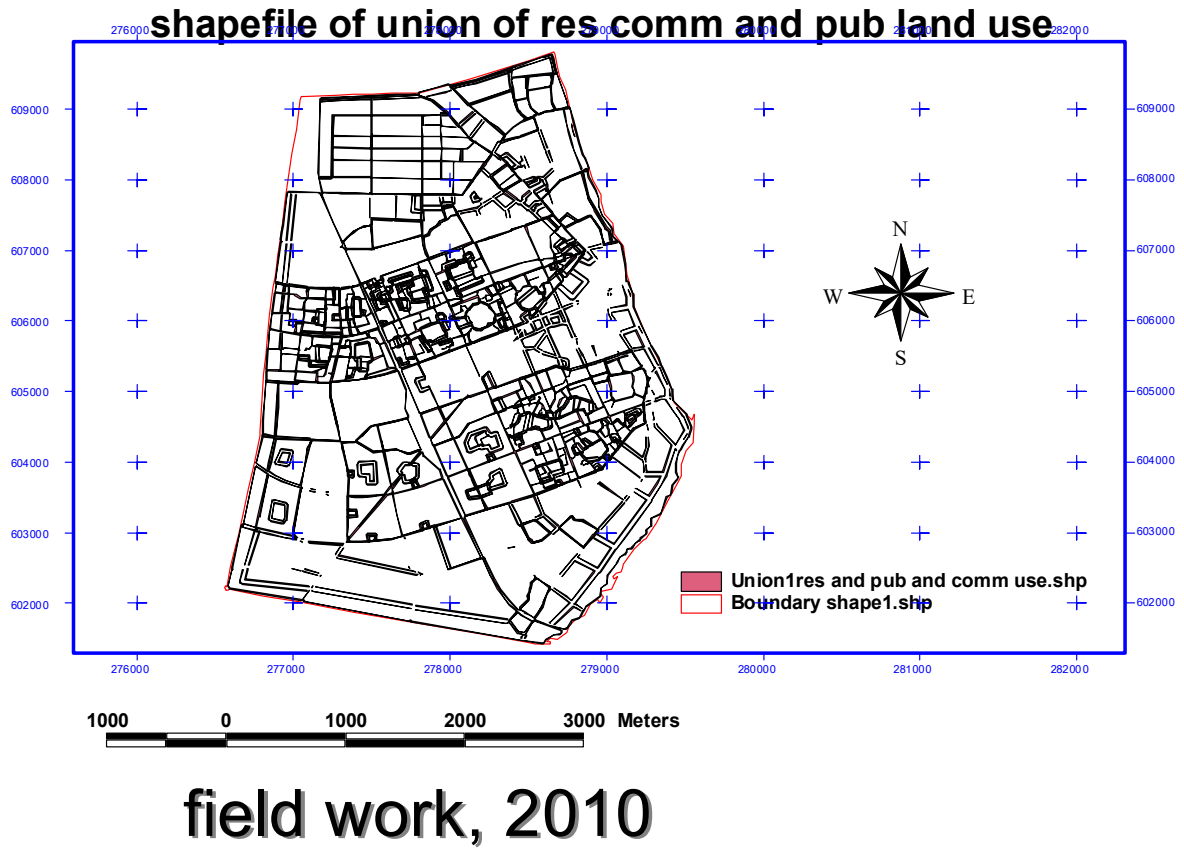

Fig 4.12.a layout of shapefile of union of residential and public use and commercial land use

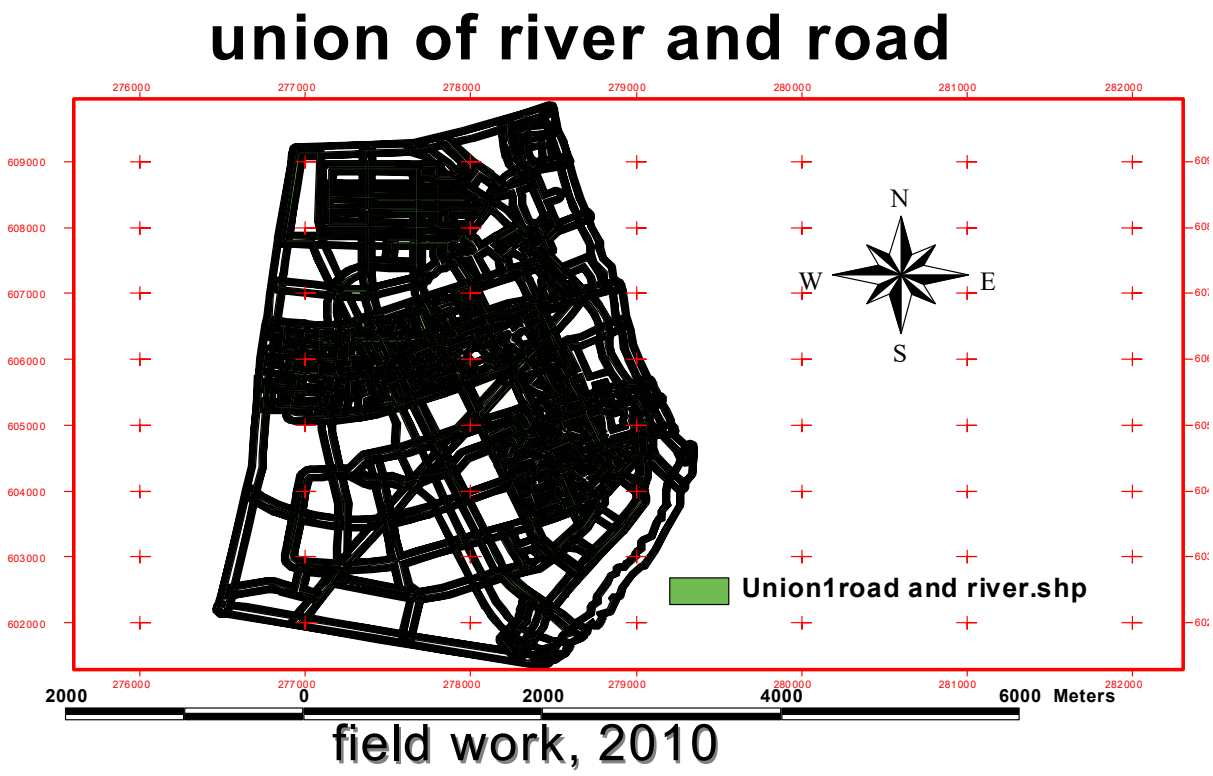

Fig 4.13 Layout of union of buffered road and river

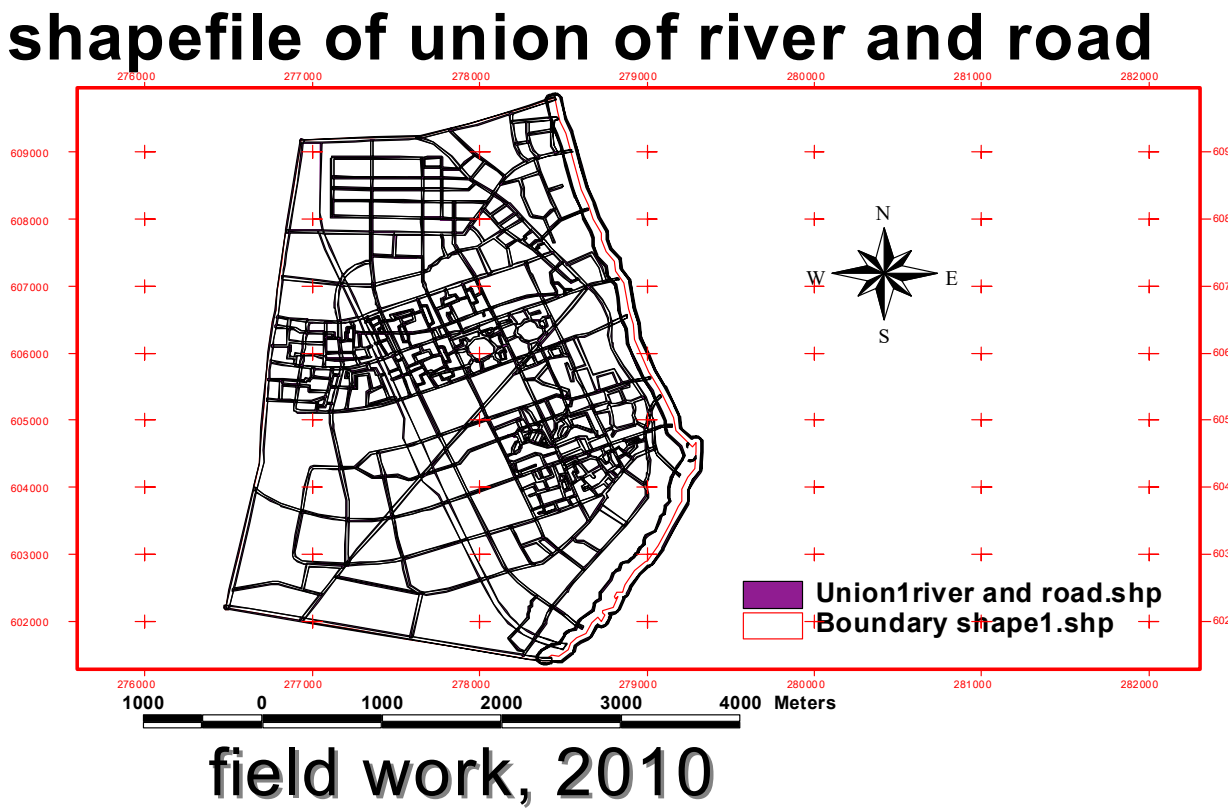

Fig 4.13.a layout of shapefile of union of river and road theme

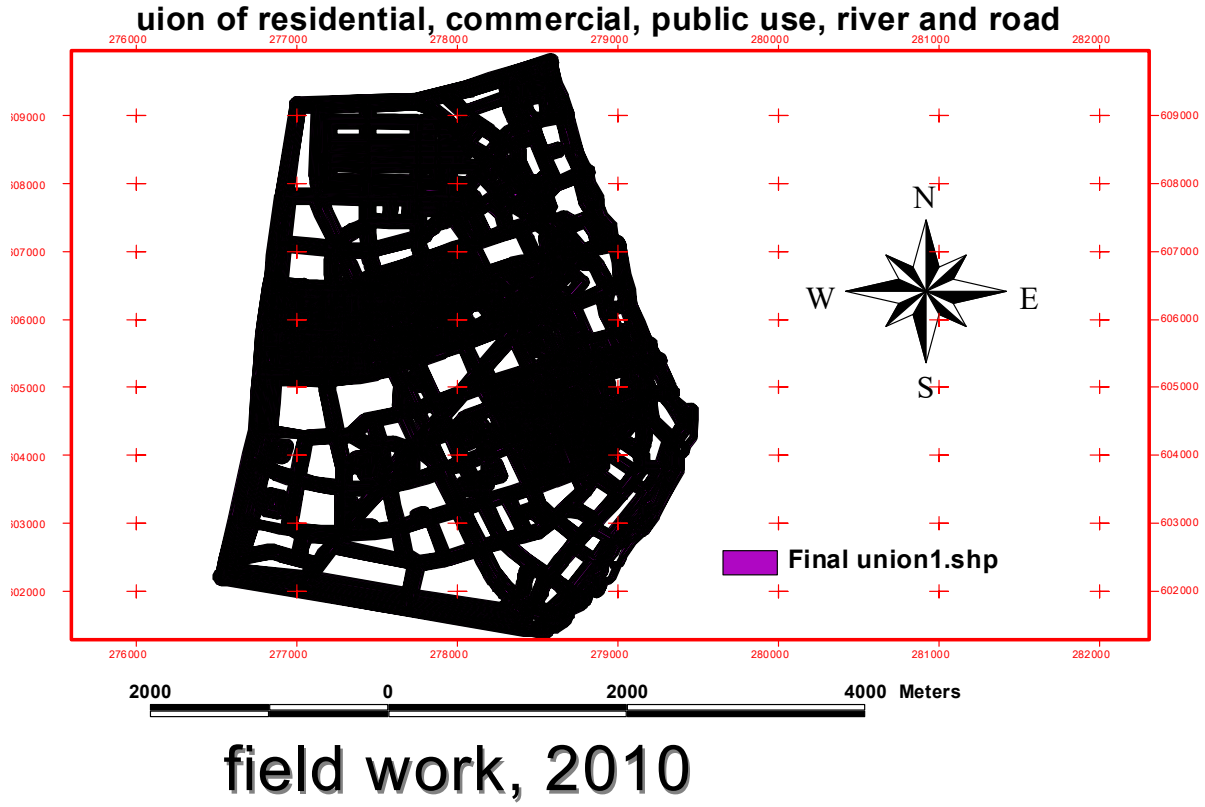

Fig 4.14 layout of the union of public, commercial and residential land use and road and river i.e. final union

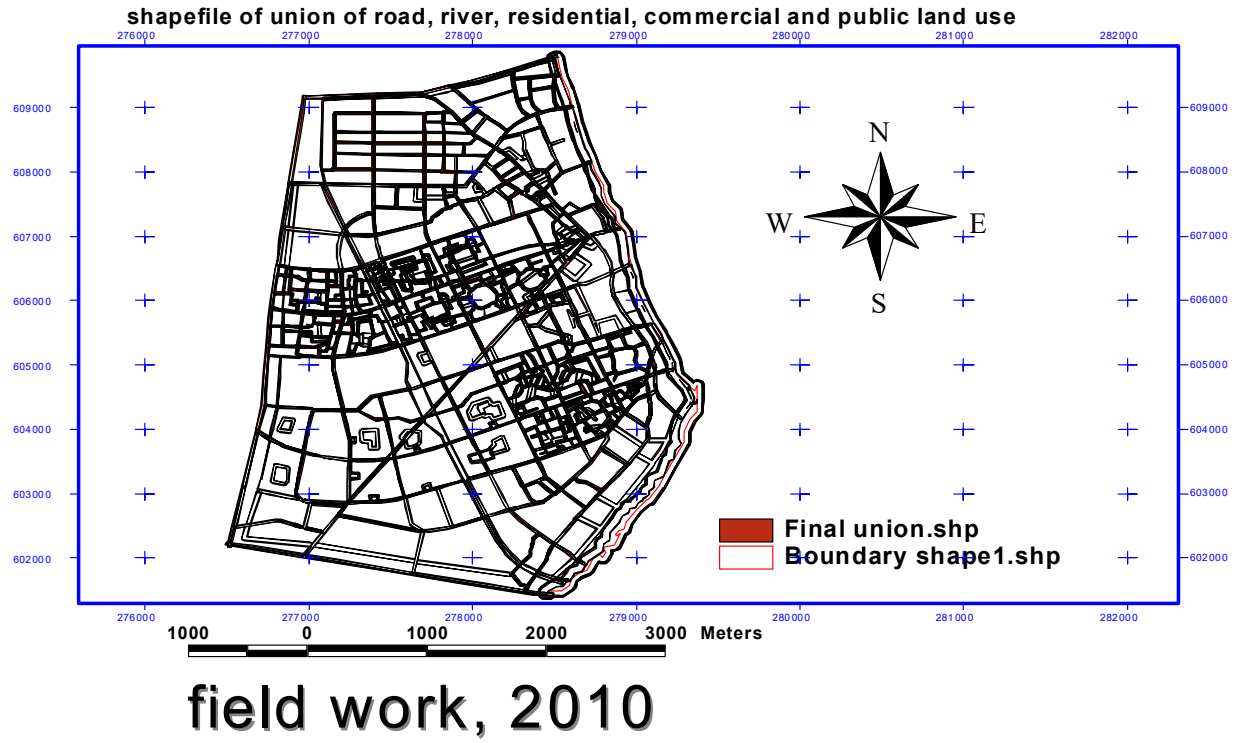

Fig 4.14.a layout of shapefile of final union

4.4.4 Polygon clipping operations

This is the spatial extraction of those features from one coverage that resides entirely within a boundary defined by features in another coverage (called clip-coverage). In line with analysis for this study, the boundary of the study area was clipped with the theme; union of commercial, public use, residential and roads to produce the candidate site for further research.

4.4.4. 1 Analysis of clipping operation

Click on ‘view’ on the tool bar menu and select ‘geo-processing wizard’ A dialogue box is shown. Select ‘clip one theme based on another’ and click on ‘next’. On the new dialogue box, select the input theme i.e. union of commercial, public use, residential,

river and roads, as well as the polygon overlay theme i.e. boundary layer. Specify the output file and click ‘finish’. The new theme will definitely show.

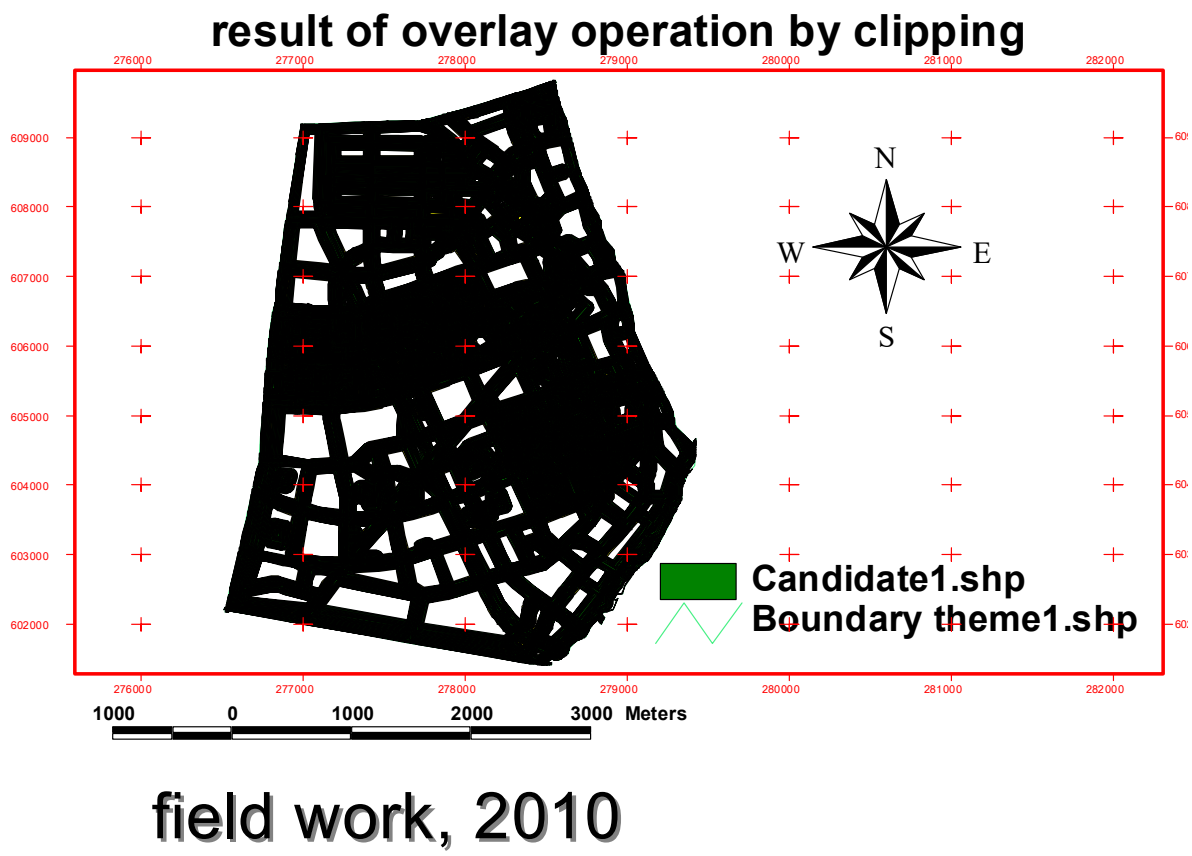

Fig 4.15 Layout of result of clipping operation (candidate site)

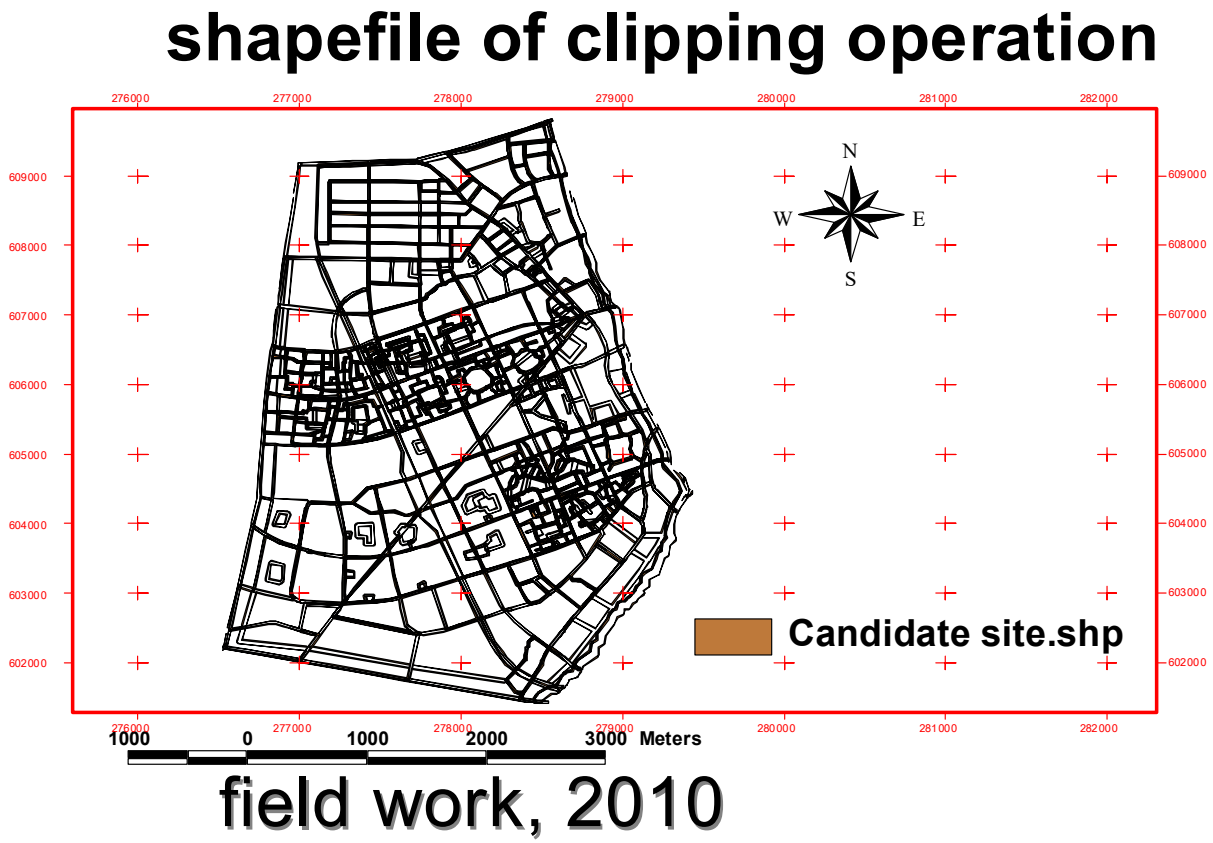

Fig 4.15.a layout of result of clipping operation (candidate's site shapefile)

4.5 SPATIAL QUERY/SEARCH

This is the major analytical operation carried out on the attribute table of various entities. The spatial search was performed by querying the database. It is the process of acquiring information from a GIS by asking spatial questions from the geographic data.

Spatial query is the process of selecting features based on location or spatial relationship (e.g. selecting all areas 20m from residential areas). Database querying is achieved through a query expression built to precisely define what to be selected. Query expressions can either be single or multiple criteria.

In this project, the single criteria query was carried out after buffering and the resultant output (in shapefile) were unioned, and clipped to form a candidate shapefile which was queried multiply to obtain most suitable sites for the present need only.

However, the future need were also incorporated by overlaying the buffered land use theme without querying and clipping the final union to form a candidate site to be queried either singly or multiply to obtain desired result.

4.5.1 Single criteria query

Single criteria query was used to determine the possible areas for solid waste collection points for all the land uses including roads. This didn't produce the final result but gave an insight to the possible areas where the collection containers can be placed. This was done using the set criteria as stated in fig 4.2. It was inputted into the query builder as follows; 10m from roads (Roads=10m) for easy collection and to prevent road blockage, 20m from residential areas (Res=20m) and 20m from commercial areas as well (com=20m) so it will be within the proximity of users and 40m from public use (public use =40m) so it wouldn't constitute nuisance to people using public facilities.

POSSIBLE AREAS FOR ROADS

(Rd Dist=10m)

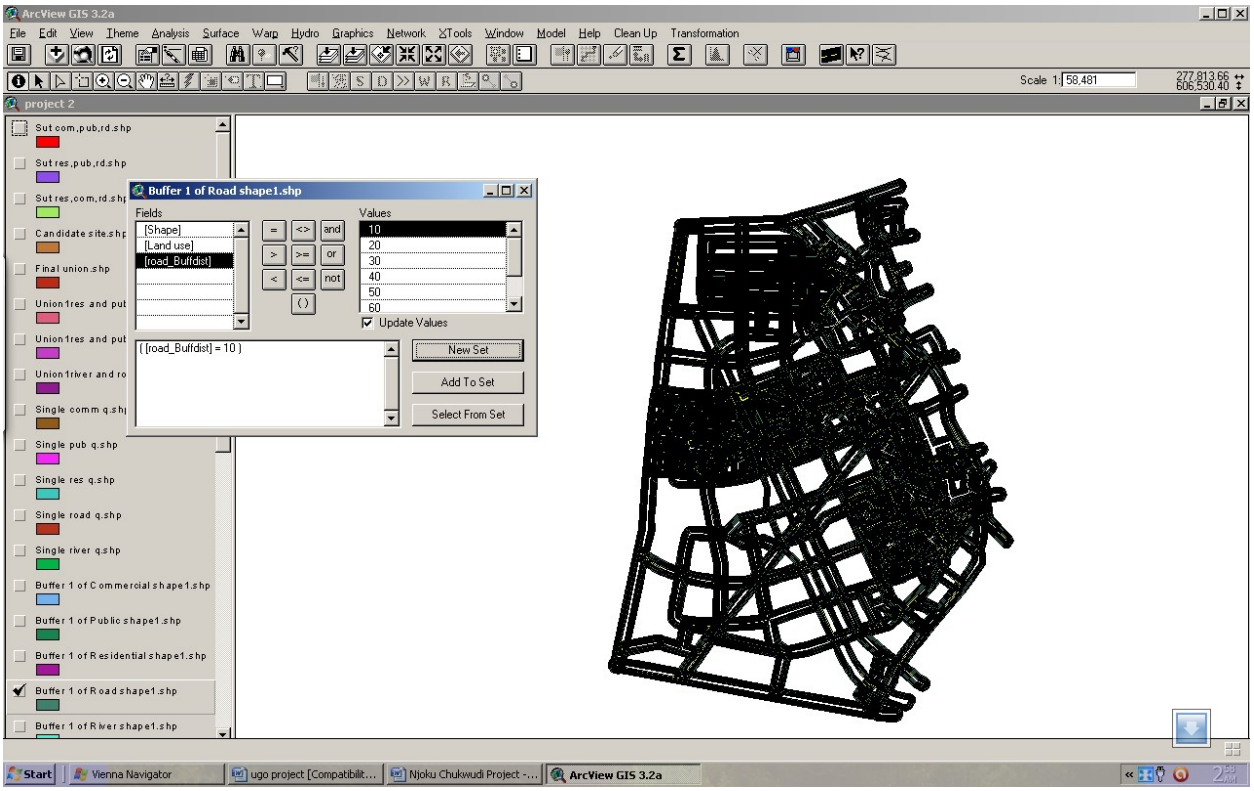

Fig 4.16 Query input and output of 10m from road

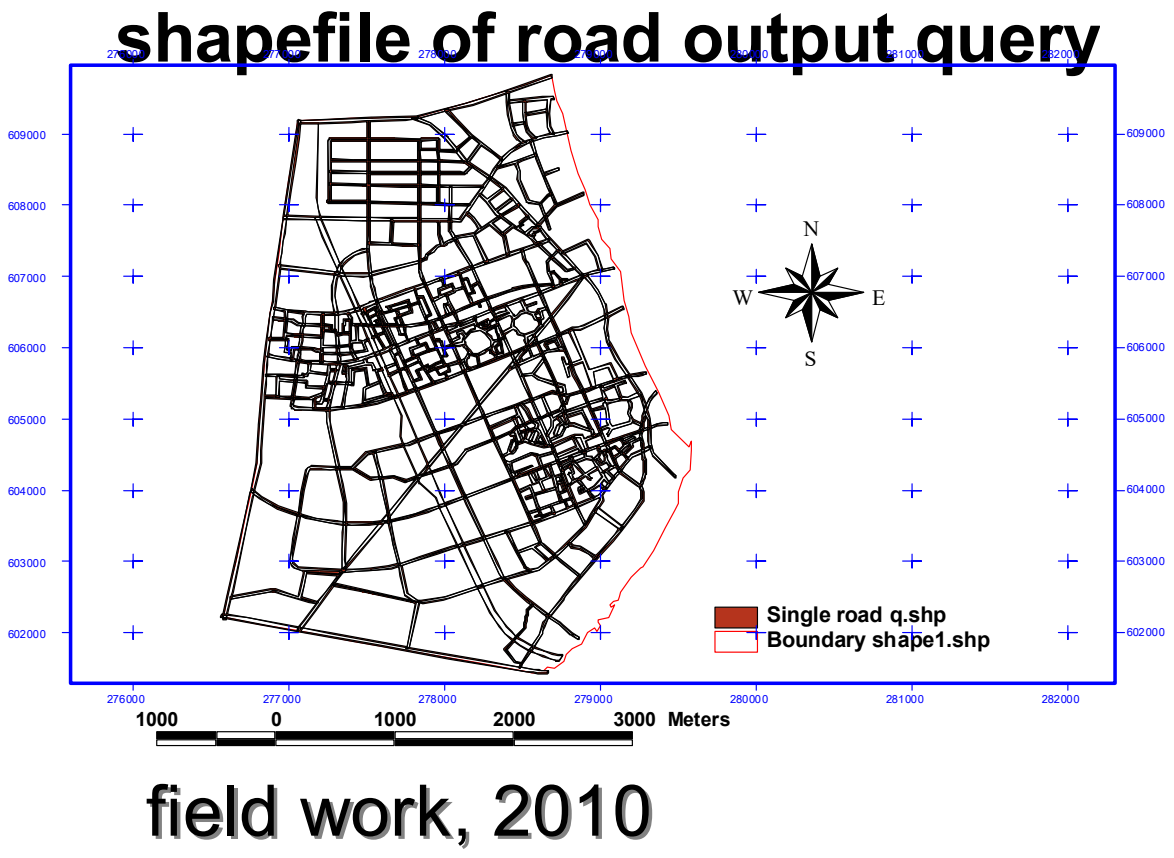

Fig 4.16.a layout of result of road query input output in shapefile

POSSIBLE AREAS FOR RESIDENTIAL

(Res Dist=20m)

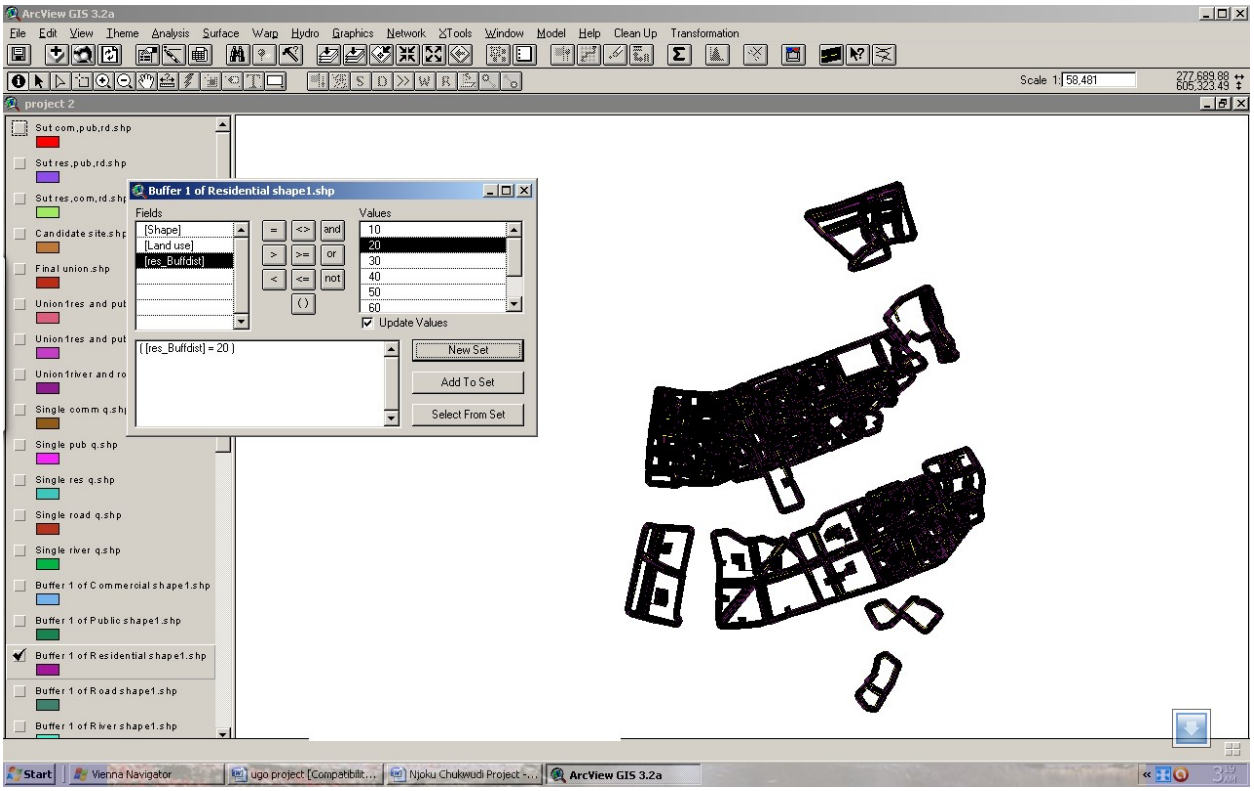

Fig 4.17 Query input and output of 20m from residential

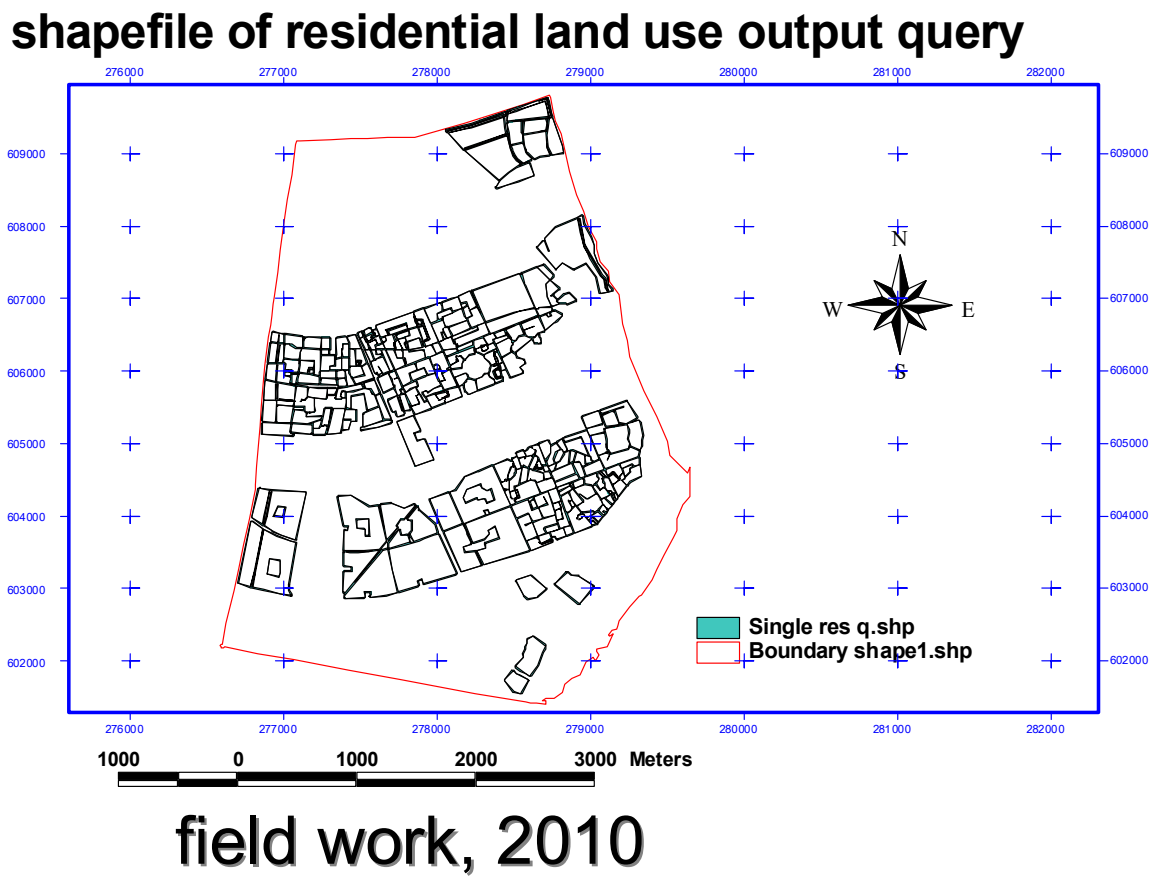

Fig 4.17.a layout of result of residential query in shapefile

POSSIBLE AREAS FOR PUBLIC USE

(Pub Use Dist=40m)

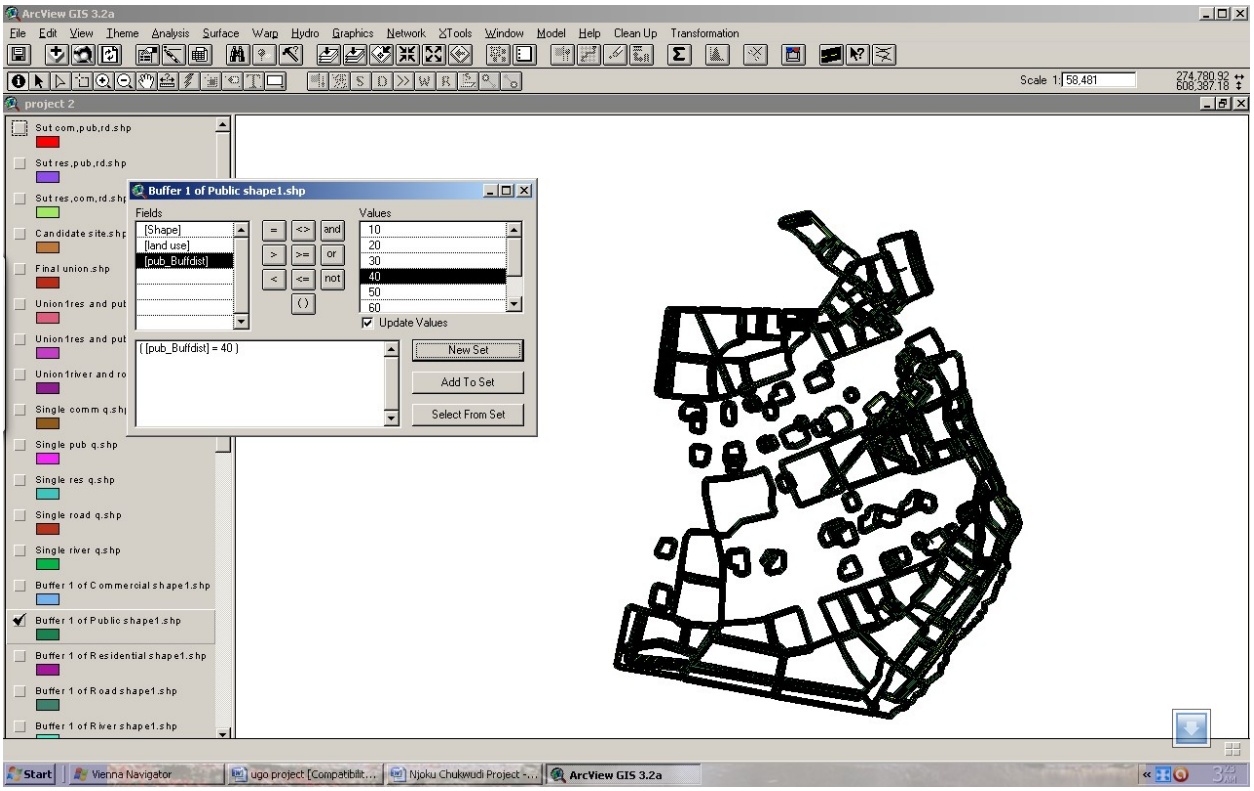

Fig 4.18 Query input and output of 40m from public use

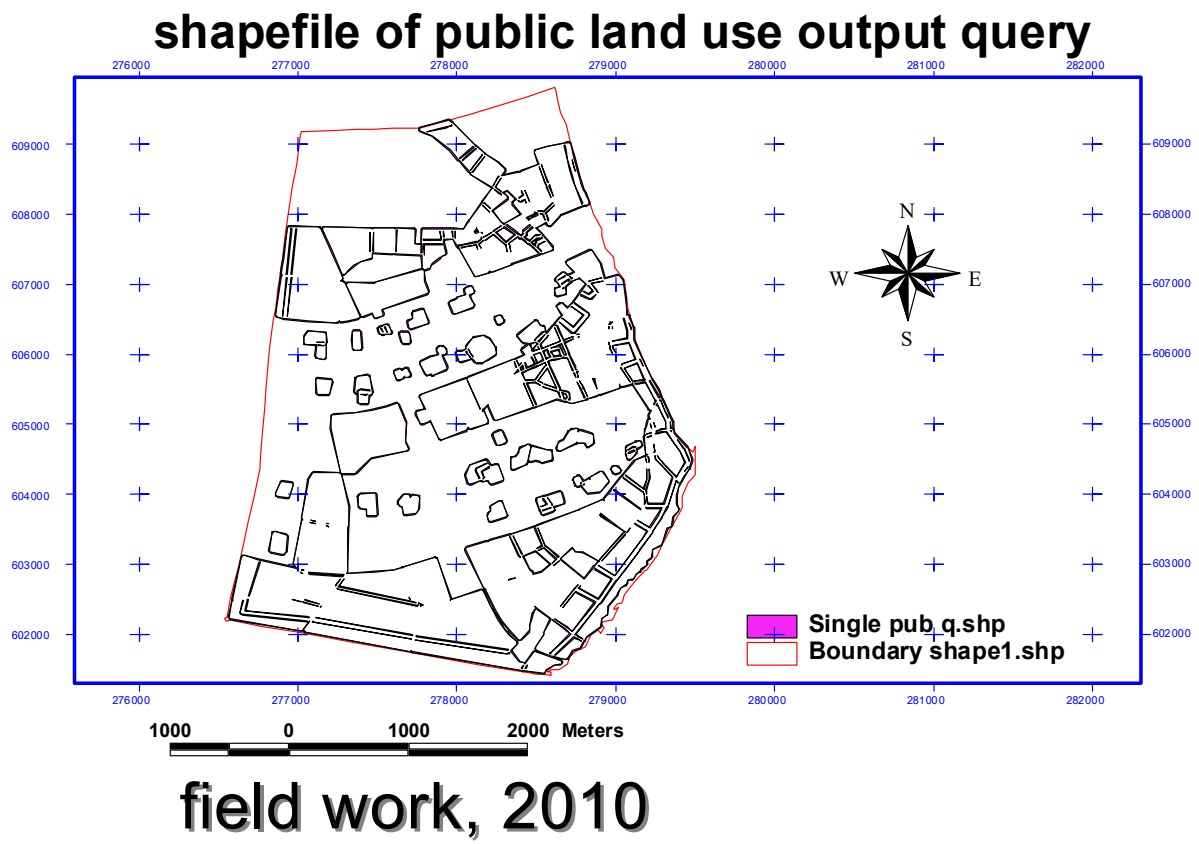

Fig 4.18.a layout of shapefile of result of public use query in shapefile

POSSIBLE AREAS FOR COMMERCIAL

(Com Dist=20m)

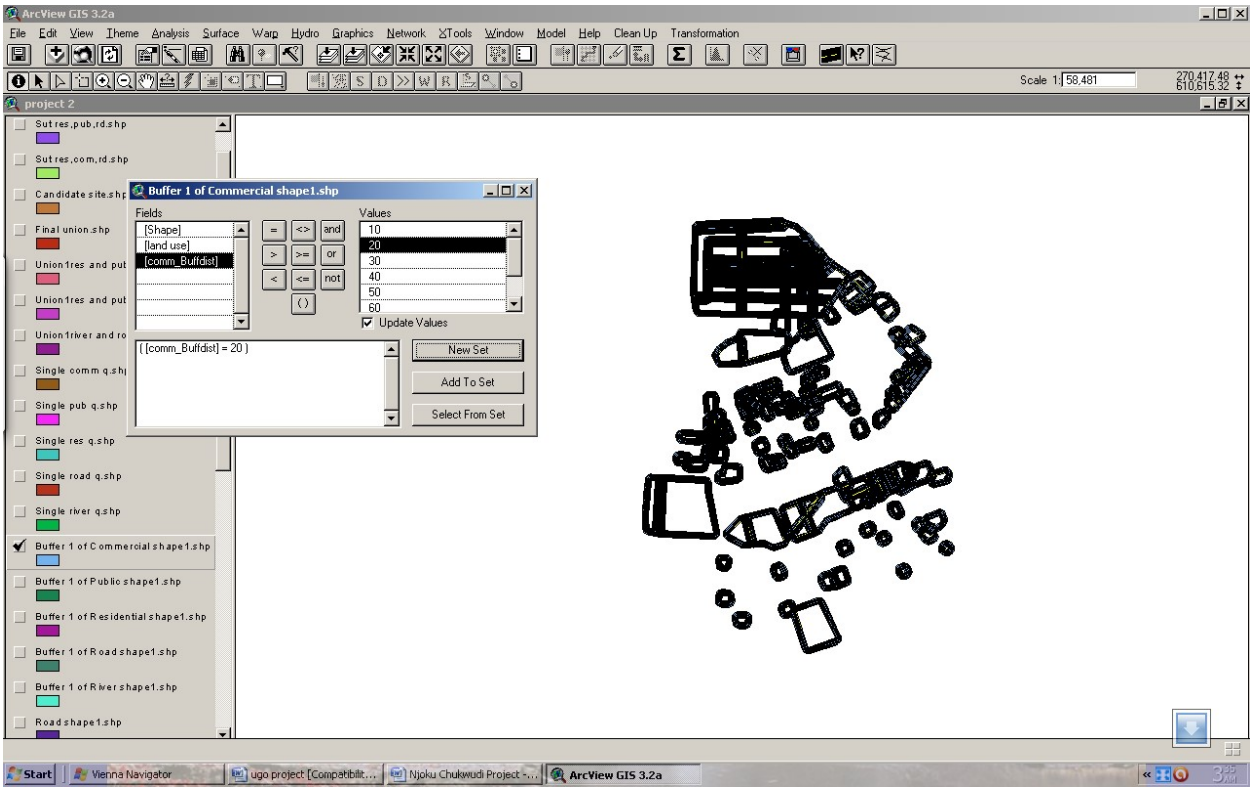

Fig 4.19 Query input and output of 20m from commercial

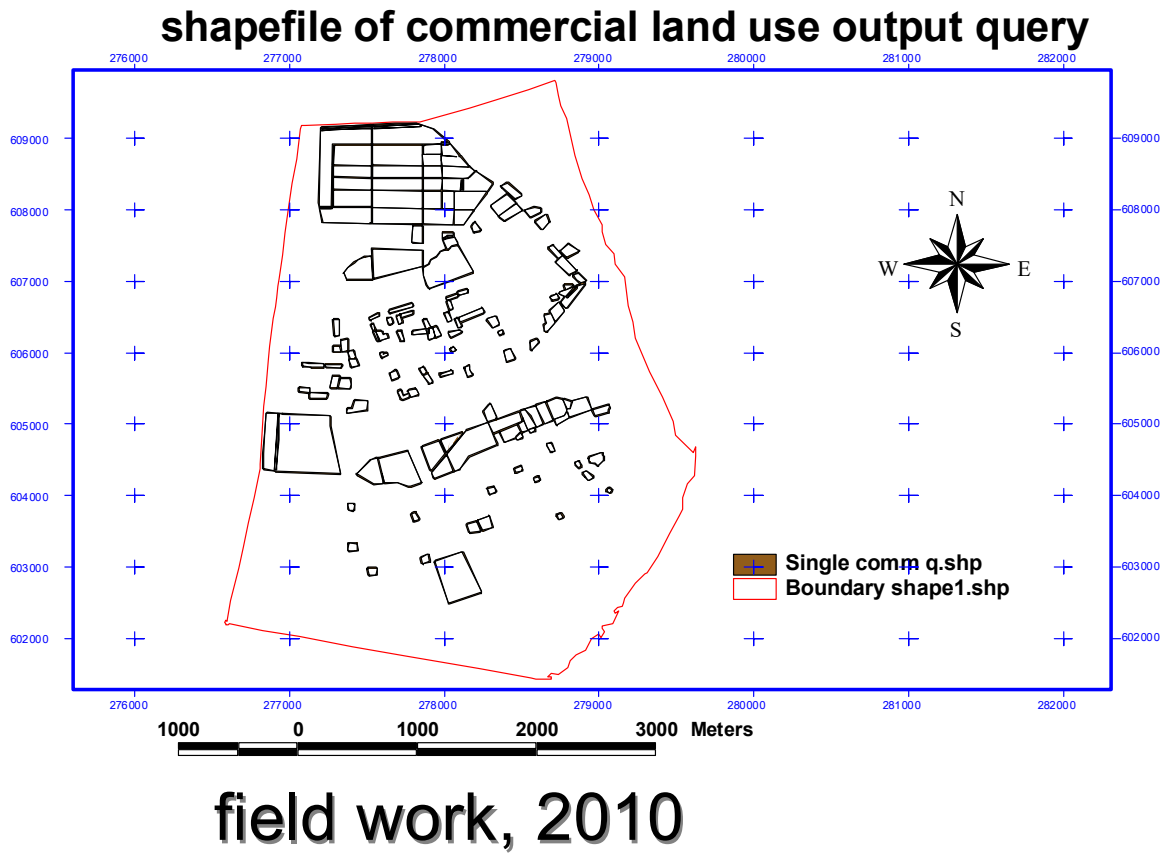

Fig 4.19.a layout of result of commercial use query in shapefile

POSSIBLE AREAS FOR RIVER

(River Dist>70m)

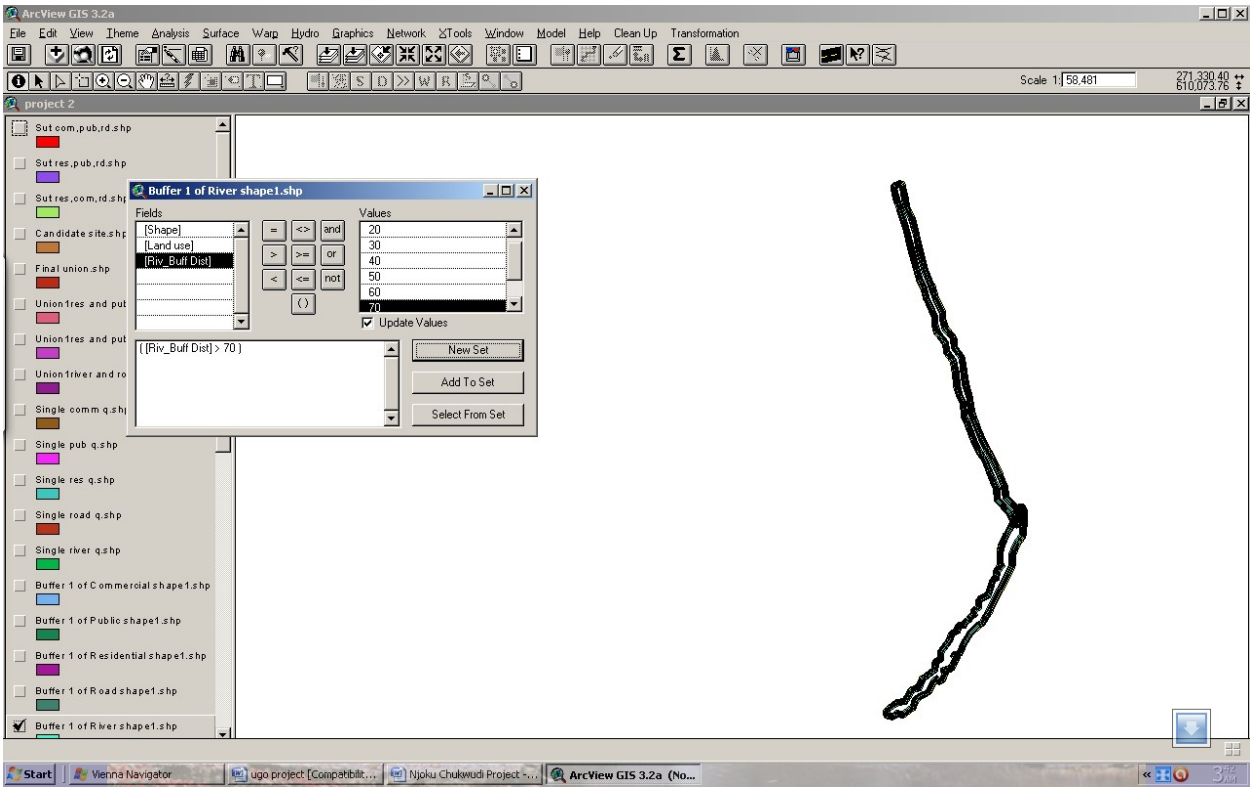

Fig 4.20 query input and output for river

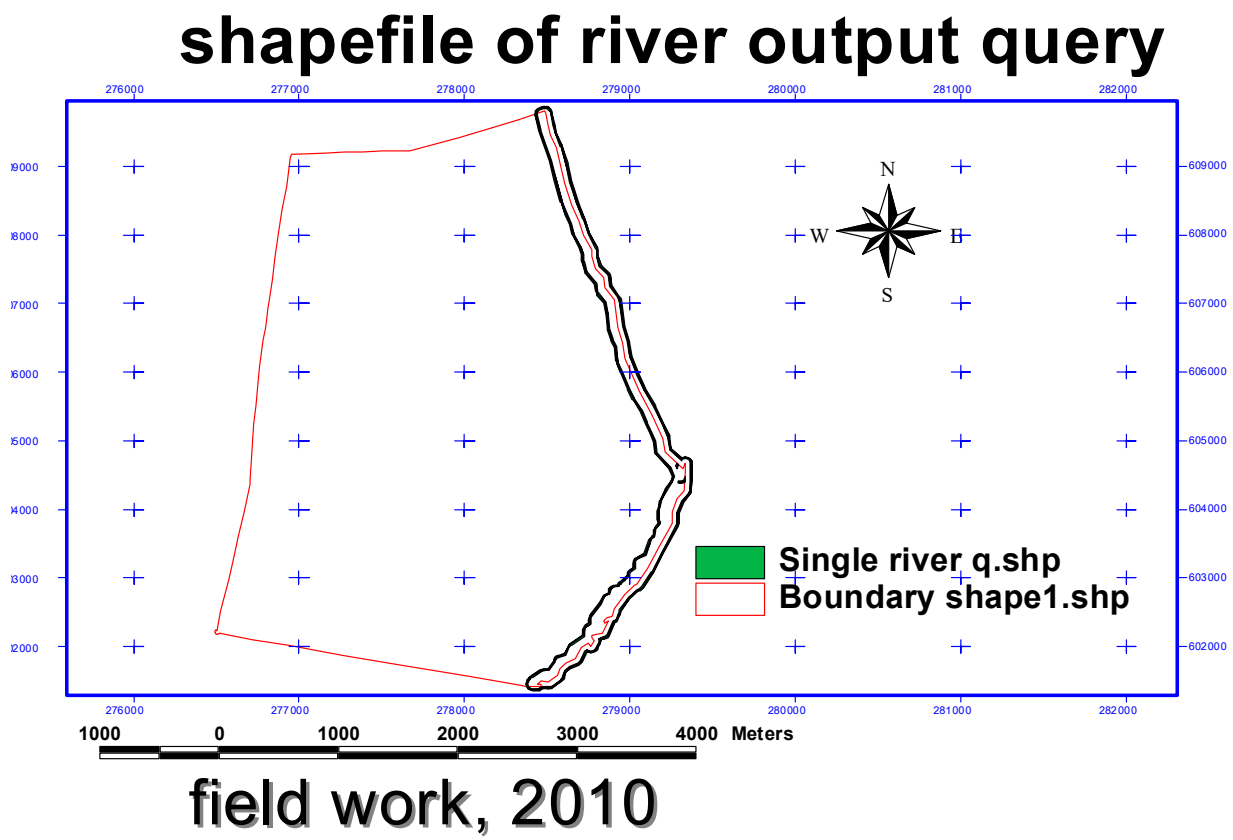

Fig 4.20.a layout of result of river query in shapefile

4.5.2 Multi criteria queries

Multi criteria queries were used to determine the suitable sites as well as the most suitable sites for solid waste collection within New Owerri area. This query combines more than one entity in a particular land uses to select the suitable sites within the land thereof. Three multiple criteria query was carried out in this project.

(i) First; identification of most suitable points within residential and commercial area at 20m interval respectively

(ii) Second; identification of suitable points on areas within residential and public land use at 20m and 40m interval respectively.

(iii) Third; identification of most suitable points on areas with commercial and public land use at 20m and 40 interval respectively

The result of this query shows sites that are suitable for users at the same time in the two land uses. The result is a union of points or areas where the land uses meet / intersect with the set criteria in place within a particular land use type.

4.5.2.1 Input for multi-criteria queries

- First: Res_BuffDist = 20 and com_Buffdist=20 and RdDist = 10
- Second: Res_Buffedist=20 and Pub_BuffDist = 40 and RdDist = 10
- Third: comm._Buffdist=20 and Pub_Buffdist=40 and RdDist = 10.

4.5.2.2 Output for multi-criteria queries

- SUITABLE SITES WITHIN RESIDENTIAL AND COMMERCIAL

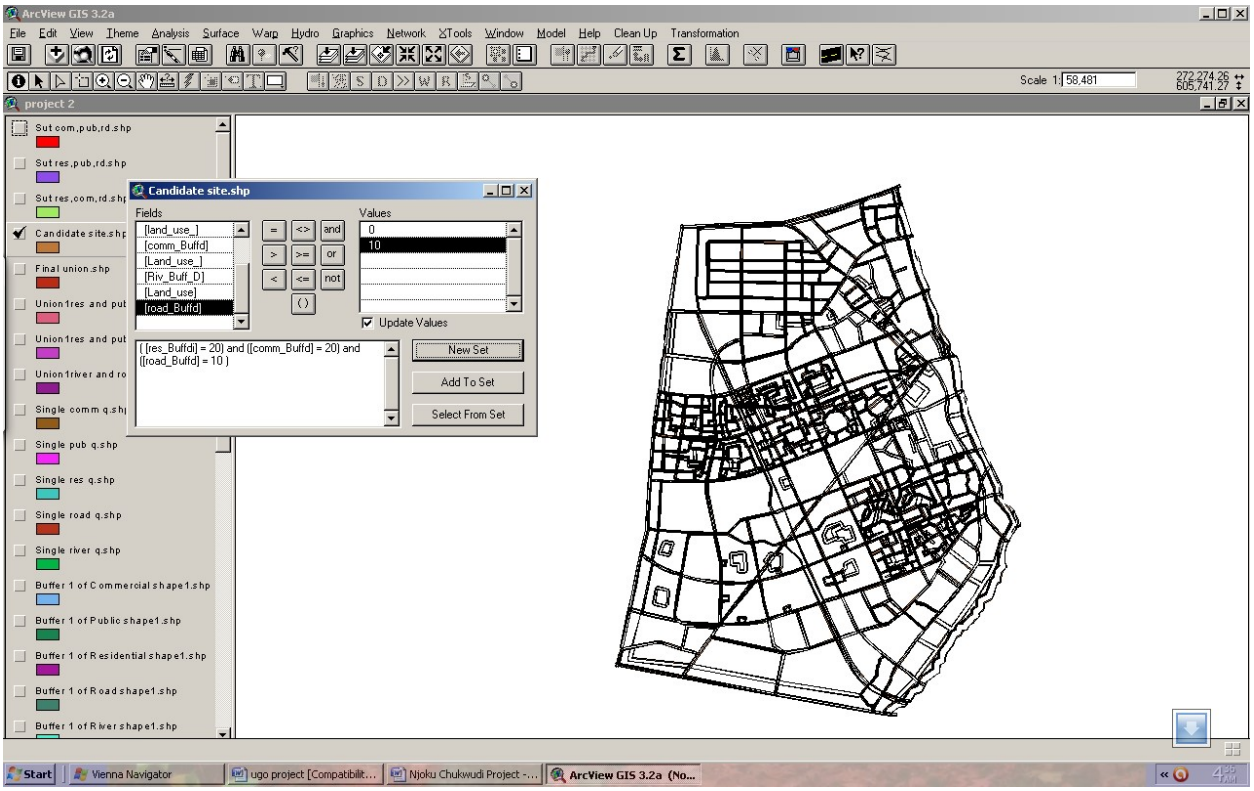

Fig 4.21 Query input and output for suitable sites within residential and commercial land use

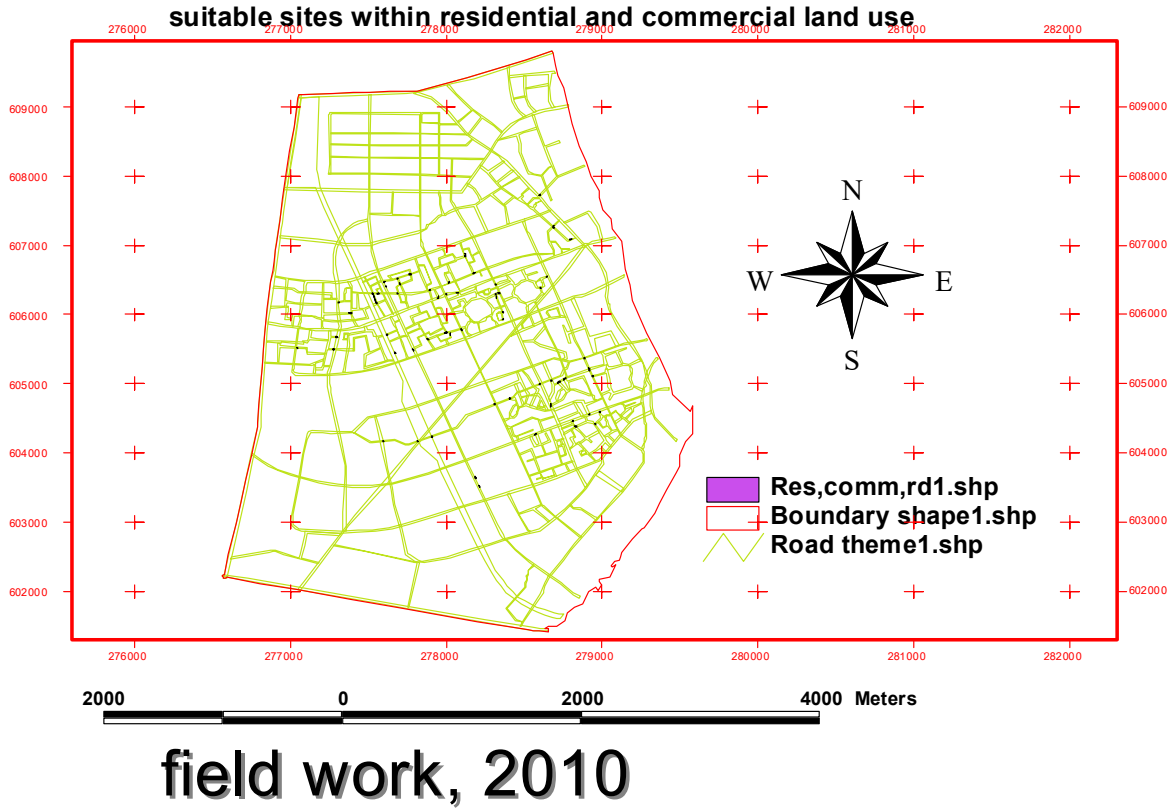

Fig 4.22 Layout of suitable sites within residential and commercial land use

- SUITABLE SITES WITHIN RESIDENTIAL AND PUBLIC USE

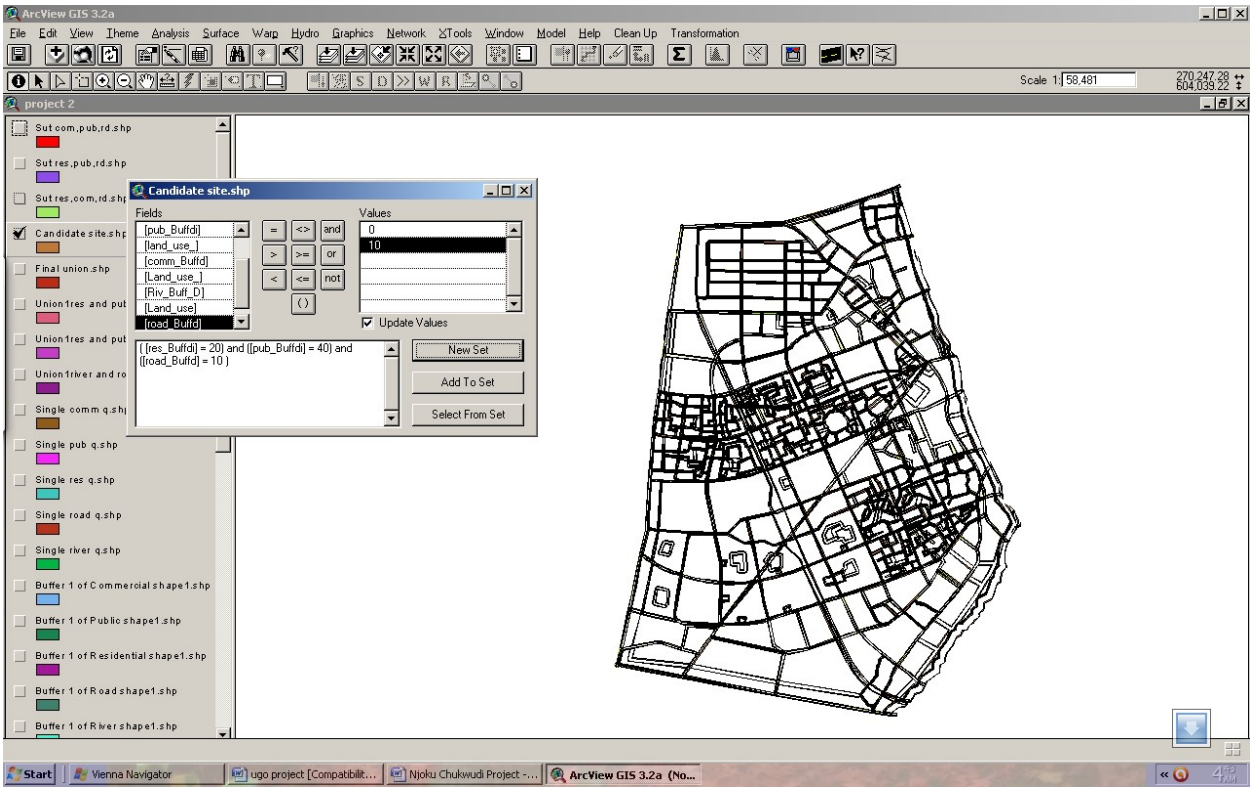

Fig 4.23 Query input and output for suitable sites within residential and public use

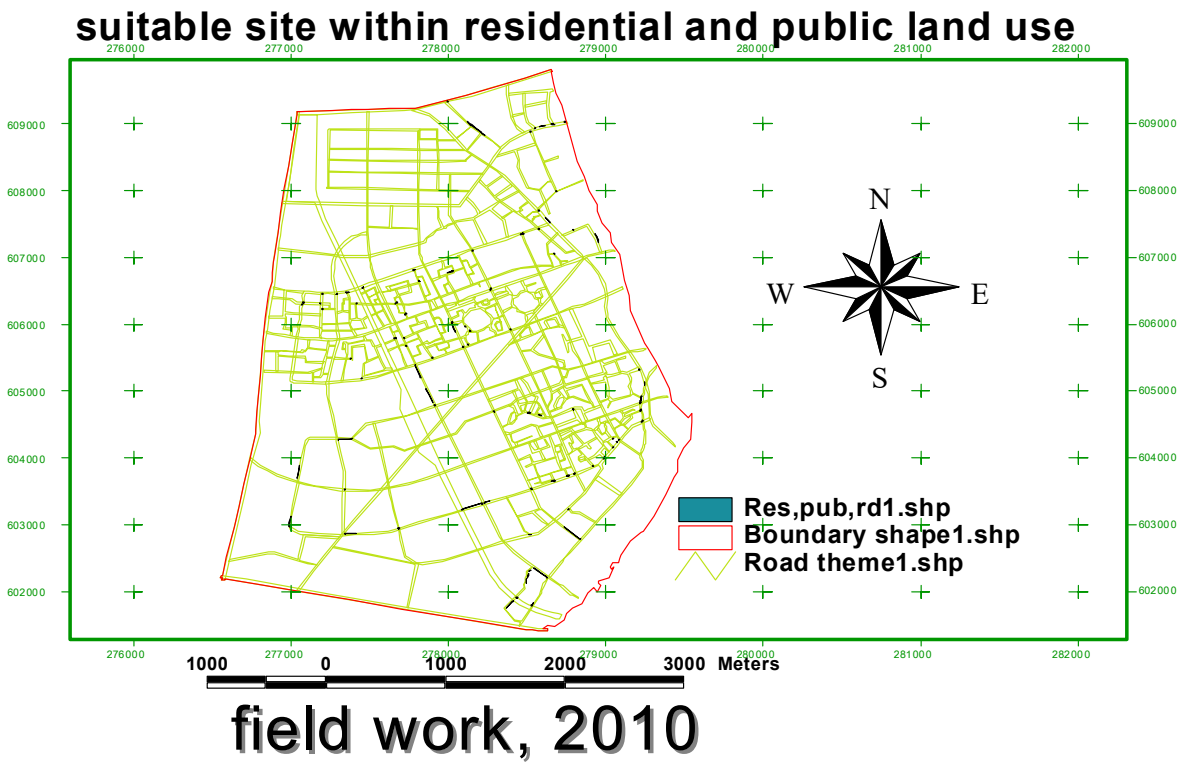

Fig 4.24 Layout of suitable sites within residential and public use

- SUITABLE SITES WITHIN COMMERCIAL AND PUBLIC USE

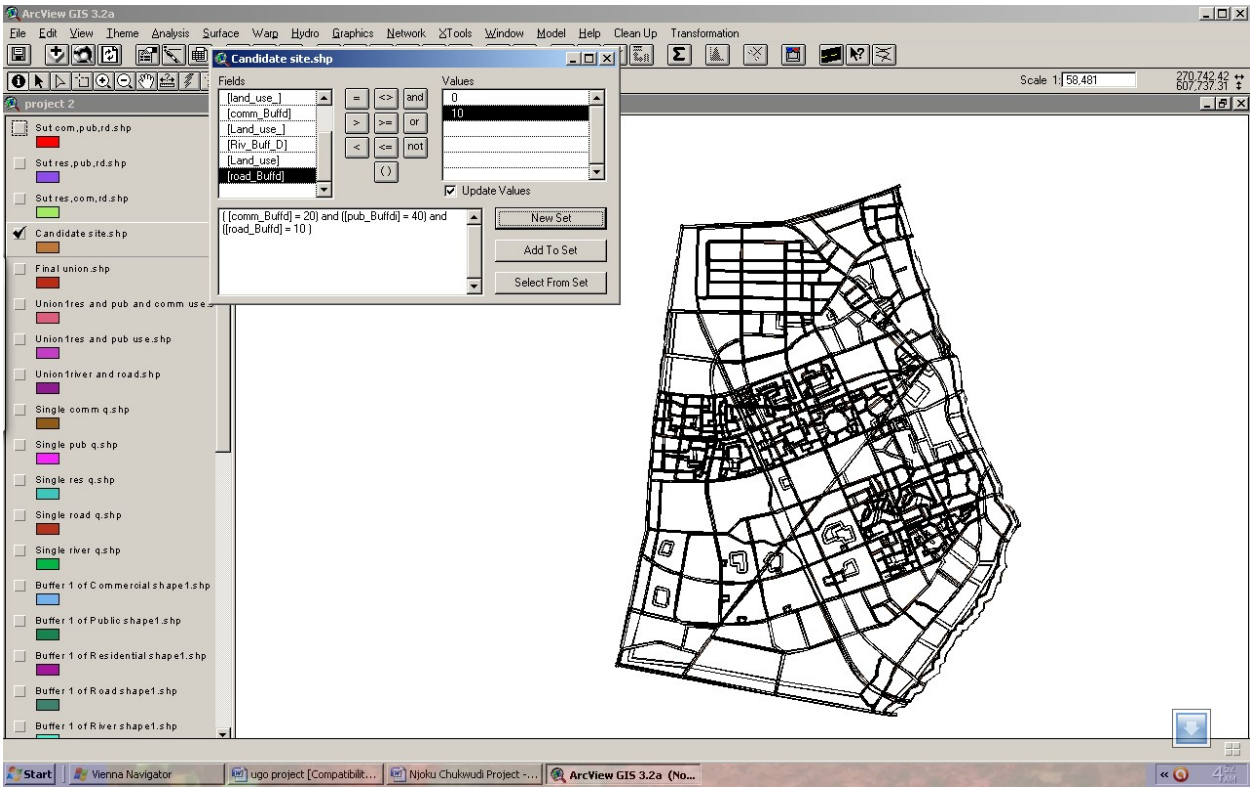

Fig 4.25 Query input and output for suitable sites within commmercial and public use

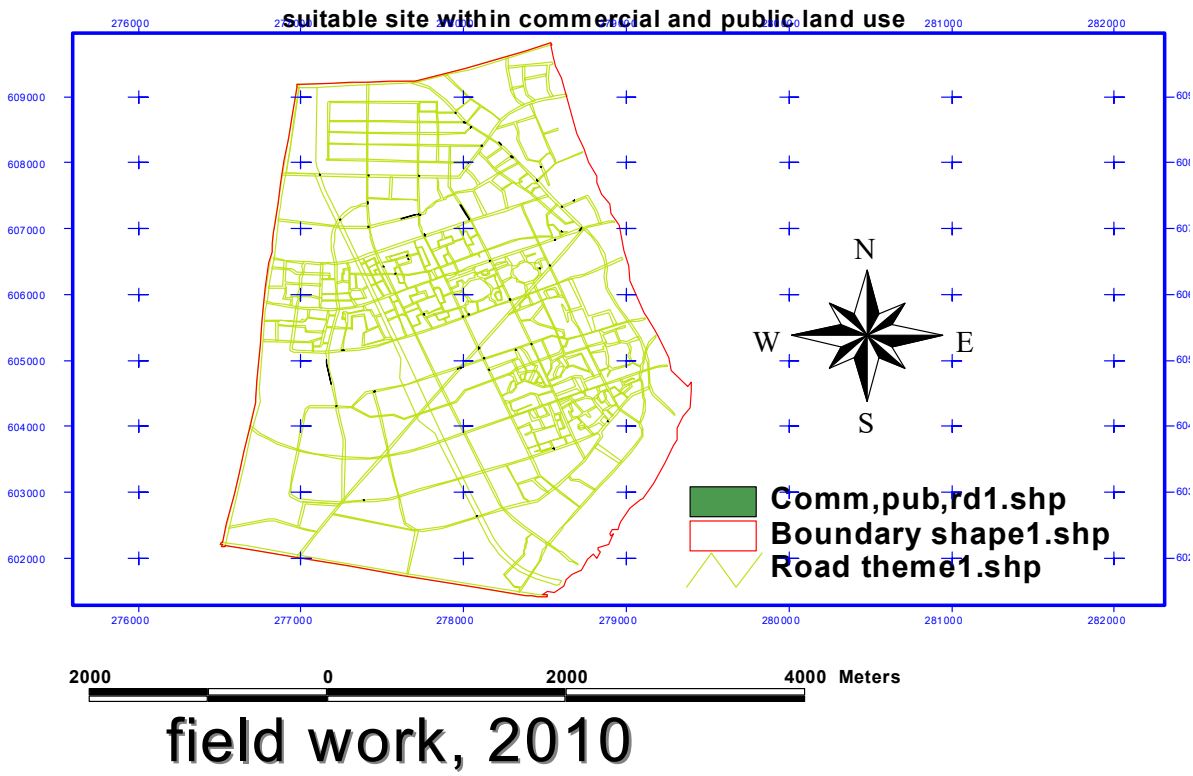

Fig 4.26 Layout of suitable sites within commercial and public use land use

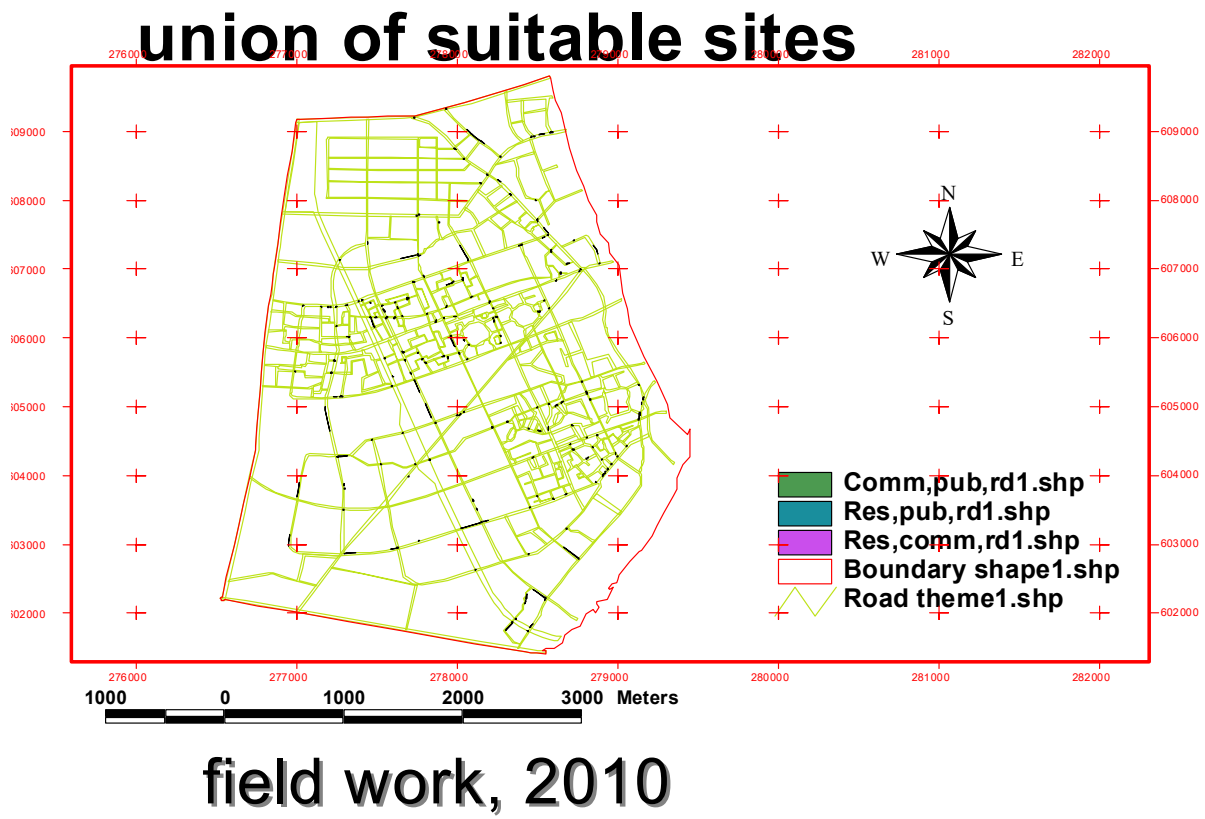

Fig 4.27 Layout of union of suitable sites within commercial, residential and public use land uses

According to the map sourced from State Ministry of Land & Survey and Owerri Capital Development Authority, New Owerri area is characterized mainly by residential areas, public use areas as well as commercial areas.

Thus, there is need to make available more bins for these areas, especially the high density residential areas.

Afterwards, points that were within 200m proximity were expunged using the measure tool on Arcview window.

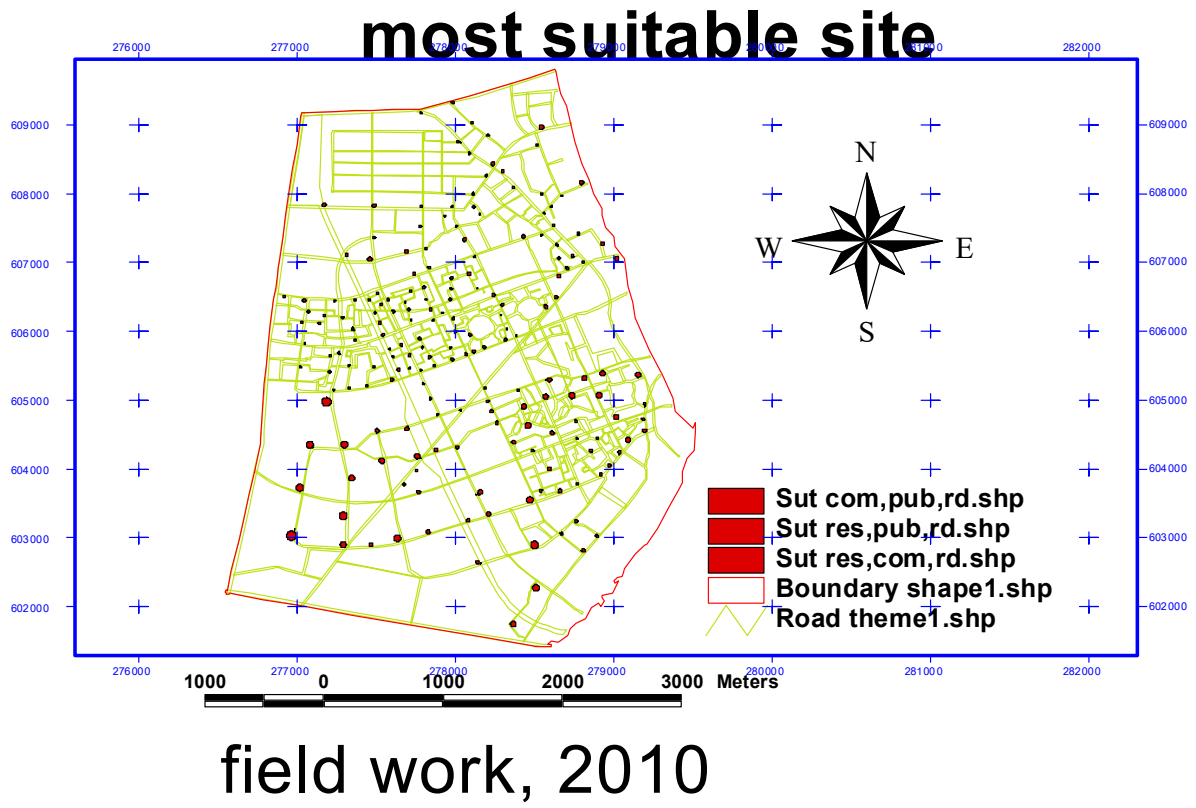

Fig 4.28 Layout of most suitable sites

4.6 DISCUSSION OF RESULT

Figures 4.22, 4.24 and 4.26 were overlaid to have a combined suitable sites (Fig. 4.27), which again was queried to have the suitable sites, after which points that were within 200m proximity were expunged using the measure tool on Arcview window (as seen in Fig 4.28) thus giving the most suitable sites for locating solid waste collection points in New Owerri.

In Fig 4.28, the collection points were identified as points in relation to their coordinate values and layout. The following coordinate values represent the locations specified by the Geographic Information Systems as well as the attributes of the points. Thus, in all the sited collection points, the distances to similar land use type are the same as stated in the criteria with respective distances of; road=10m, commercial land use=20m, public land use=40m, river >70m and residential land use=20m.

INDUSTRIAL LAYOUT

This has nine collection points with respective coordinate values of:

278421.01E&609192.64N, 278897.32E&608762.14N, 279053.03E&608606.42N, 279282.03E&608285.83N, 279126.31E&608029.36N, 278851.52E&608837.00N, 278411.85E&607827.84N, 277770.67E&607827.84N, 277092.85E&607837.00N

AMAKAOHIA POCKET LAYOUT

This has five collection points with respective coordinate values of:

278824.04E &609320.88N, 279098.83E & 609063.41N, 279300.35E & 608872.05N, 280042.29E &608991.13N, 280427.00E &609046.09N

ARUGO LAYOUT

This has four collection points with respective coordinate values of:

279.538.50E & 608340.79N, 279987.33E & 608716.34N, 280060.61E & 608020.20N, 280616.19 & 608203.39

UMUJECHI NEKEDE VILLAGE LAYOUT/NEW OWERRI SOUTH

This has four collection points with respective coordinate values of:

280332.46E&603065.10N, 280550.21E&603255.63N, 280822.39E&603037.88N, 280631.86E&602847.35N.

UMUGWULE NEKEDE VILLAGE/NEW OWERRI SOUTH

This has only one collection point of 279965.00E & 602888.18N.

UMUMBAZU NEKEDE VILLAGE/NEW OWERRI SOUTH

This has two collection points with respective coordinates of:

279992.22E&602262.14N and 279651.98E&601758.59.

PUBLIC BUILDING/NEW OWERRI SOUTH

This has only one collection point with coordinate values of 279189.26E&602670N.

AREA H LAYOUT

This has four collection points with respective coordinate value of:

280196.36E&604017.76N, 280060.27E&603677.52N, 280278.02E&603691.13N, 280880.21E&603772.79N.

AREA G LAYOUT

This has five collection points with respective coordinate values of:

280550.21E&604412.43N, 280836.00E&604439.65N, 280754.35E&604276.34N, 281121.80E&604249.12N, 280890.44E&603936.10N.

AREA F LAYOUT

This has three collection point with respective coordinate value of:

281257.96E&604453.26N, 281475.65E&604589.35N and 281217.07E&604439.65N.

AREA E LAYOUT

This has three collection points with respective coordinate values of:

280659.08E&605310.26N, 280509.38E&605092.90N and 280550.21E&604725.45N.

AREA C LAYOUT

This has four collection points with respective coordinate values of:

280904.05E&605378.70N, 280890.44E&605092.90N, 281366.77E&605378.70N
281462.04E&604956.81N.

COMMERCIAL DISTRICT LAYOUT

This has nine collection points with respective coordinate values of:

278222.99E&604548.53N, 278359.09E&604181.07N, 278616.67E&604279.34N,
278944.29E&604834.32N, 279325.36E&605011.25N, 279393.41E&604861.54N,
279760.86E&605160.95N, 280101.10E&605065.68N 280169.14E&605297.04N.

AREA R LAYOUT

This has three collection points with respective coordinate values of:

279338.97E&603364.51N, 279883.34E&603595.87N and 279230.09E&603677.52N.

AREA P LAYOUT

This has two collection points with respective coordinate values of:

279447.84E&604643.79N and 278989.86E&604317.17N.

AREA B LAYOUT

This has five collection points with respective coordinate values of:

279815.30E&604902.37N, 279842.52E&604643.79N, 279651.98E&604398.82N, 280196.36E&604521.31N 279937.78E&604289.95N.

AREA U LAYOUT

This has only one collection point with coordinate value of 278495.18E&603105.93N.

AREA U'A LAYOUT

This has only one collection point with coordinate value of 279053.17E&603282.85N.

AREA T LAYOUT

This has three collection points with respective coordinate values of:

278168.56E&603759.18N, 278359.09E&603976.93N and 278386.31E&603677.52N.

FEDERAL MINISTRY OF WORKKS & HOUSING/SITE SERVICES SCHEME LAYOUT

This has three collection points with respective coordinate values of:

276630.69E&603078.71N, 277351.99E&602929.00N and 277351.99E&603364.51N.

AREA V LAYOUT

This has two collection points with respective coordinate values of:

277488.09E&603881.66N and 277841.93E&604126.63N.

AREA W LAYOUT

This has two collection points with respective coordinate values of:

277773.06E&602888.18N and 278073.29N

SECRETARAIT LAYOUT

This has only one collection point with coordinate value of 279284.53E&605174.56N.

PUBLIC BUILDING/EXHIBITION GROUND LAYOUT NEW OWERRI WEST

This has five collection points with respective coordinate values of:

277134.24E&604984.03N, 276889.27E&604371.60N, 276739.57E&603745.57N, 277365.60E&604357.99N, 277814.71E&604602.96N.

AREA A LAYOUT

This has seven collection points with respective coordinate values of:

278862.98E&606194.71N, 279487.80E&606246.77N, 279088.61E&605925.68N, 279591.94E&606055.86N, 279574.59E&605582.29N, 279279.53E&605778.16N,

AREA N LAYOUT WORLDBANK

This has ten collection points with respective coordinate values of:

278.584.25E&606168.18N, 278406.47E&605895.21N, 278876.21E&606001.81N, 278434.20E&605775.09N, 278819.13E&605771.83N, 278533.69E&605629.93N, 278027.90E&605678.86N, 278848.49E&605595.68N, 278598.93E&605504.34N and 278414.62E&605435.83N.

PUBLIC BUILDING LAYOUT

This has fifteen collection points with respective coordinate values of:

279661.35E&608077.86N, 279826.25E&607366.25N, 279140.68E&607791.48N, 278741.49E&607678.66N, 278889.01E&607531.13N, 279010.51E&607305.50N, 278481.14E&607192.69N, 278463.79E&608858.89N, 278524.54E&606923.67N, 278377.01E&607522.46N, 278229.48E&607175.33N, 278298.90E&606845.56N, 277760.86E&607366.25N, 277717.47E&607062.52N, 277396.38E&607123.26N.

WORLD BANK AREA M LAYOUT

This has nine collection points with respective coordinate values of:

278437.75E&606672.00N, 278472.47E&606481.08N, 278533.21E&606316.20N, 278281.55E&606177.35N, 278706.77E&606264.13N, 278186.09E&606426.37N, 278264.19E&606602.58N, 277977.81E&606455.05N, 278047.24E&606307.52N

AREA S LAYOUT

This has four collection points with respective coordinate values of:

277514.05E&606459.65N, 277342.80E&606199.93N, 277476.94E&606051.51N, 277808.34E&605874.56N

AREA X LAYOUT

This has eight collection points with respective coordinate values of:

276540.80E&606511.02N, 276809.08E&606462.50N, 277228.64E&606448.23N, 276869.02E&606302.67N, 277094.49E&606237.03N, 276786.25E&606128.57N, 277017.43E&606125.72N, 276820.50E&605831.75N

ONITSHA YOUTH CENTRE LAYOUT

This has seven collection points with respective coordinate values of:

280052.92E&607407.97N, 280297.30E&607270.24N, 280306.18E&607074.74N, 280488.36E&607123.61N, 280417.26E&606919.22N, 280634.98E&607012.53N, 280266.20E&606483.79N,

AREA D LAYOUT

This has three collection points with respective coordinate values of:

279525.29E&606379.38N, 279736.35E&605940.61N, 280114.02E&606368.27N,

AREA L LAYOUT

This has six collection points with respective coordinate values of:

279158.73E&607079.18N, 279069.87E&606834.80N, 278831.05E&606640.41N, 278814.38E&606462.69N, 279180.95E&606623.75N, 279375.34E&606529.33N,

NEW D LAYOUT

This has six collection points with respective coordinate values of:

277417.06E&605509.23N, 277768.06E&605494.16N, 278010.96E&605306.59N, 277668.17E&605206.70N, 277425.57E&605175.36N, 277222.93E&605149.62N,

AREA Y LAYOUT

This has four collection points with respective coordinate values of:

277277.16E&605700.16N, 277162.99E&605646.23N, 277157.28E&605417.90N, 276754.85E&605489.25N,

FEDERAL LOW COST HOUSING ESTATE TAN2

This has six collection points with respective coordinate values of:

277812.93E606580.51N, 277700.11E&606481.08N, 277865.00E&606402.98N, 277804.25E&606272.81N, 277847.64E&606125.28N, 277891.03E&605943.04N

FEDERAL LOWCOST HOUSING ESTATE TAN1

This has six collection points with respective coordinate values of:

278003.85E&605726.09N, 278151.38E&605804.19N, 278029.88E&605647.98N, 278246.83E&605658.66N, 278246.83E&605457.07N, 278116.66E&605465.74N

The available portions specified by the system are the most suitable sites. Thus, the local government can now use their discretion to place the bins (containers) at strategic points as specified. If the bins are properly placed at these points, New Owerri territory will be;

- A healthy environment for the inhabitants.
- Void of health hazards associated with indiscriminate dumping of solid wastes.
- Made a clean area in contrast to other cities of Nigeria and in line with the state governments' programme of ensuring a "clean and green" city.
- Void of induced flooding caused by blocking of drainage as a result of indiscriminate dumping of solid wastes.
- Made a model area in terms of efficient and effective solid waste management.

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1 SUMMARY

The database required for this project was designed using the conceptual and logical design, after which the actual implementation of the database was carried out with the physical design.

The data required were captured through scanning and georeferencing an analogue map obtained from State ministry of Land & Survey and Owerri Capital development Authority. The Georeferenced map was digitized using AutoCAD Land Development 2i. The digitized drawing was then exported into Arc view 3.2a, where the layers were converted to shape files and then polygonized. Afterwards, attribute tables were created for each land use and finally, the required analyses were performed using the same Arc View 3.2a.

5.2 CONCLUSION

The use of GIS technology is a better way of decision making on complex issues related to the earth (land suitability) and the people living therein, such as agriculture, forestry, health, resource management, land administration, water resource planning, location analysis etc. In this study, GIS technology was applied for decision making in municipal solid waste management via the selection of possible and suitable points for solid waste collection. This was done in line with the purpose and set criteria for selection of suitable sites for waste collection points. The geographic database was tested by defining and executing some criteria, which gave the result as shown in chapter four. Thus, this has shown the capabilities of GIS as a system to solve spatial problems and provide information to aid decision making.

5.3 RECOMMENDATIONS

As a result of the findings of the study and the limitations encountered, the following recommendations are made for proper solid waste management;

- Decision makers and stakeholders in the management of solid waste should adopt Geographic Information System (GIS) as a tool in decision making in their everyday operations.
- Digital land use maps should be introduced in the aspect of waste collection, since it is an important tool for planning and management of waste in given geographical entities. It helps in having a holistic view of the entire area at a glance.
- GIS laboratories should be introduced in higher institutions and government agencies. This will enable the production and updating of spatial data such as maps.
- GIS projects should be funded by the government, private agencies and other organizations. This will enhance human development and growth especially in our developing economy.
- Large scaled projects should be carried out in phases for efficient and effective actualization of good result and high visibility.

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APPENDIXES

APPENDIX I

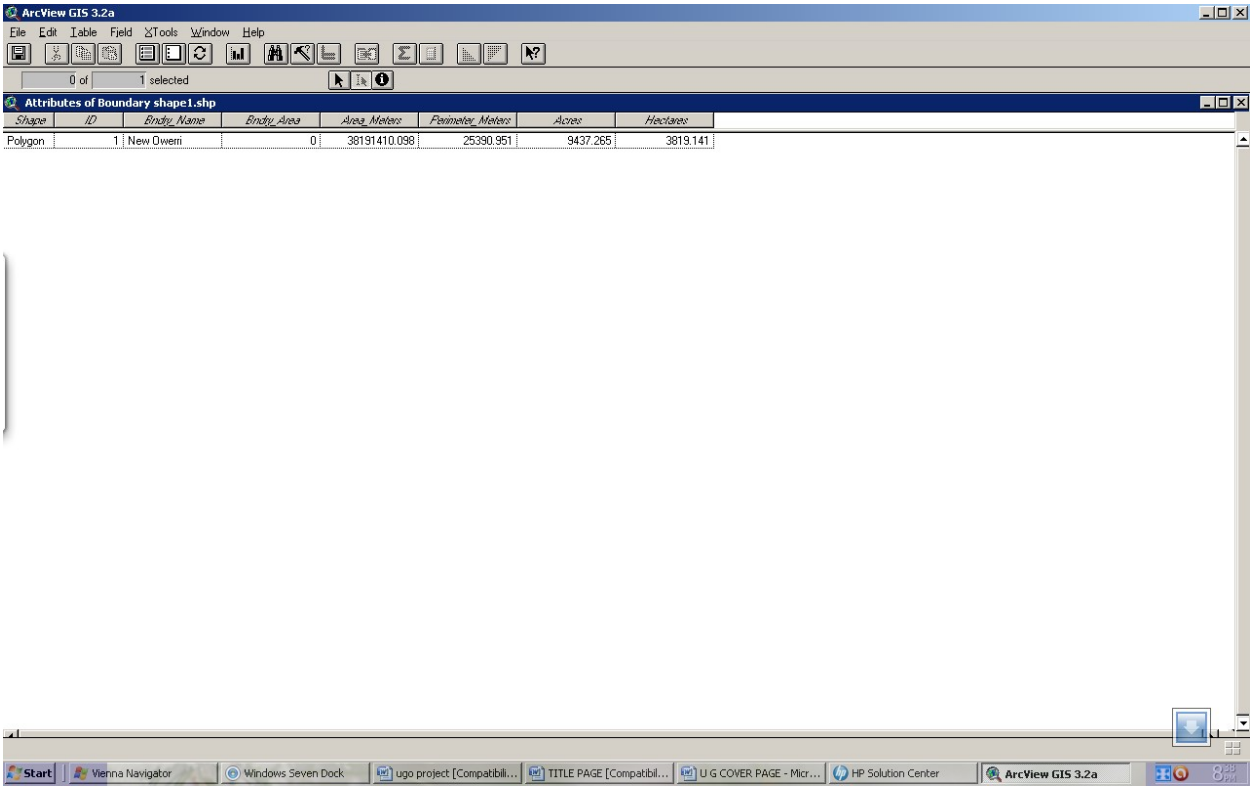
SYMBOL	MEANING
Com	Commercial land use
Com_BuffDist	Commercial buffer distance
ECTAH1	Eastern Central Tangent Arterial Highway road 1
ECTAH2	Eastern Central Tangent Arterial Highway road 2
NCTAH	Northern Central Tangent Arterial Highway road
NMTAH1	Northern Middle Tangent Arterial Highway road 1
NMTAH2	Northern Middle Tangent Arterial Highway road 2
NMTAH3	Northern Middle Tangent Arterial Highway road 3
NETF	Northern External Tangent/Freeway road
Pub	Public land use
Pub_BuffDist	Public use Buffer Distance
Res	Residential land use
Res_BuffDist	Residential use Buffer Distance
SETF	Southern External Tangent/Freeway road
SCTAH	southern Central tangent Arterial Highway road
SMTAH1	Southern Middle Tangent Arterial Highway road 1
SMTAH2	Southern Middle Tangent Arterial Highway road 2
WETF	Western External Tangent/freeway road

WMTAH1	Western middle Tangent Arterial Highway road 1
WMTAH2	Western middle Tangent Arterial Highway road 2
WMTAH3	Western middle Tangent Arterial Highway road 3

APPENDIX II

ATTRIBUTE TABLE FOR VARIOUS LAND USE TYPES

Table 3.3 Attribute table for boundary



Attributes of Boundary shape1.shp

Shape	ID	Bndry_Name	Bndry_Area	Area_Meters	Perimeter_Meters	Acres	Hectares
Polygon	1	New Owerri	0	38191410.098	25390.951	9437.265	3819.141

Table 3.4 Attribute of commercial land use

ArcView GIS 3.2a

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0 of 134 selected

Attributes of Commercial shape1.shp

Shape	ID	Ld_use_Area(layout)	Ld_use_Type	Ld_use_Status	Ld_use_Popdsty
Polygon	1	industrial	commercial	jelius berger	high
Polygon	2	industrial1	commercial	cocacola	high
Polygon	3	industrial2	commercial		high
Polygon	4	industrial3	commercial		high
Polygon	5	industrial4	commercial		high
Polygon	6	industrial5	commercial		high
Polygon	7	industrial6	commercial		high
Polygon	8	industrial7	commercial		high
Polygon	9	industrial8	commercial		high
Polygon	10	industrial9	commercial		high
Polygon	11	industrial10	commercial		high
Polygon	12	industrial11	commercial		high
Polygon	13	industrial12	commercial		high
Polygon	14	industrial13	commercial		high
Polygon	15	industrial14	commercial		high
Polygon	16	industrial15	commercial		high
Polygon	17	industrial16	commercial		high
Polygon	18	industrial17	commercial		high
Polygon	19	industrial18	commercial		high
Polygon	20	industrial19	commercial		high
Polygon	21	industrial20	commercial		high
Polygon	22	industrial21	commercial		high
Polygon	23	industrial22	commercial		high
Polygon	24	industrial23	commercial		high
Polygon	25	arugo	commercial	petrol station	medium
Polygon	26	arugo1	commercial	park	high
Polygon	27	ekwmma residential	commercial	nnpc petrol stn	medium
Polygon	28	public building	commercial	printing press	high
Polygon	29	public building1	commercial	stores	low
Polygon	30	public building2	commercial	stores	low
Polygon	31	public building3	commercial	stores	low
Polygon	32	public building4	commercial	stores	low
Polygon	33	public building5	commercial	park	high
Polygon	34	public building6	commercial	comunicatn centr	high
Polygon	35	pubic building7	commercial	wholesale market	high
Polygon	36	new owerri south	commercial	park	high
Polygon	37	area G	commercial	market	high
Polygon	38	area G1	commercial	shoping complex	high

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ArcView GIS 3.2a

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Attributes of Commercial shape1.shp

Shape	ID	Ld_use_Area(layout)	Ld_use_Type	Ld_use_Status	Ld_use_Popdsty
Polygon	39	area G2	commercial	shoping complex	high
Polygon	40	area G3	commercial	activity centre	high
Polygon	41	area C	commercial	activity centre	high
Polygon	42	area E	commercial	concorde hotel	high
Polygon	43	area E1	commercial	activity centre	high
Polygon	44	area B	commercial	shoping complex	high
Polygon	45	area B1	commercial	petrol station	
Polygon	46	area B2	commercial	activity centre	high
Polygon	47	area B3	commercial	petrol station	
Polygon	48	area H	commercial	activity centre	high
Polygon	49	area H1	commercial	activity centre	high
Polygon	50	area P	commercial	activity centre	high
Polygon	51	area R	commercial	activity centre	high
Polygon	52	area U'A	commercial	market	high
Polygon	53	area T	commercial	market	high
Polygon	54	area U	commercial	activity centre	high
Polygon	55	area V	commercial	activity centre	high
Polygon	56	area W	commercial	activity centre	high
Polygon	57	area W1	commercial	activity centre	high
Polygon	58	exhibition	commercial	park	high
Polygon	59	commercial district	commercial	market	high
Polygon	60	commercial district1	commercial	hotel, mkt, bank	high
Polygon	61	commercial district2	commercial	bus terminal	high
Polygon	62	commercial district3	commercial	bus terminal	high
Polygon	63	commercial district4	commercial		high
Polygon	64	commercial district5	commercial	hotel, mkt, bank	high
Polygon	65	commercial district6	commercial		high
Polygon	66	commercial district7	commercial		high
Polygon	67	commercial district8	commercial		high
Polygon	68	commercial district9	commercial		high
Polygon	69	commercial district10	commercial	sun city hotel	high
Polygon	70	commercial district11	commercial	alseason hotel	high
Polygon	71	commercial district12	commercial		high
Polygon	72	commercial district13	commercial	shoping mall	high
Polygon	73	area D	commercial	petrol statn(pf)	high
Polygon	74	area D1	commercial	plaza hotel	high
Polygon	75	onitsha/youths	commercial	pf/mr bigs	high
Polygon	76	onitsha/youths1	commercial	pf,shops,banks	high

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ArcView GIS 3.2a

File Edit Table Field XTools Window Help

0 of 134 selected

Attributes of Commercial shape1.shp

Shape	ID	Ld_use_Area(layout)	Ld_use_Type	Ld_use_Status	Ld_use_Popdsty
Polygon	77	onitsha/youths2	commercial	fast food	high
Polygon	78	onitsha/youths3	commercial	shops	medium
Polygon	79	arugo2	commercial	shops	medium
Polygon	80	onitsha/youths4	commercial	shops	medium
Polygon	81	onitsha/youths5	commercial	activity centre	
Polygon	82	onitsha/youths6	commercial	shops	medium
Polygon	83	onitsha/youths7	commercial		medium
Polygon	84	area A	commercial	first bank	high
Polygon	85	area A1	commercial	newcastle hotel	high
Polygon	86	area A2	commercial	dreamland hotel	high
Polygon	87	area A3	commercial	crownplaza hotel	high
Polygon	88	area A4	commercial	activity centre	high
Polygon	89	area N	commercial	shops	medium
Polygon	90	area N1	commercial	shops	medium
Polygon	91	area N2	commercial	shops	medium
Polygon	92	area N3	commercial	shops	medium
Polygon	93	federal lowcost tan 1	commercial	petrol station	medium
Polygon	94	federal lowcost1 tan 1	commercial	corner shops	medium
Polygon	95	federal lowcost2 tan 1	commercial	motor park	high
Polygon	96	area L	commercial	shops	medium
Polygon	97	area L1	commercial	shops	medium
Polygon	98	area L2	commercial	shops	medium
Polygon	99	area L3	commercial	shops	medium
Polygon	100	area L4	commercial	shops	medium
Polygon	101	area L5	commercial	shops	medium
Polygon	102	area M	commercial	worldbank mkt	high
Polygon	103	area M1	commercial	shops	medium
Polygon	104	area M2	commercial	shops	medium
Polygon	105	area M3	commercial	shops	medium
Polygon	106	area M4	commercial	shops	medium
Polygon	107	area M5	commercial	shops	medium
Polygon	108	area M6	commercial	shops	medium
Polygon	109	area M7	commercial	shops	medium
Polygon	110	area M8	commercial	shops	medium
Polygon	111	federal lowcost tan2	commercial	shops	medium
Polygon	112	federal lowcost1 tan2	commercial	shops	medium
Polygon	113	federal lowcost2 tan2	commercial	shops	medium
Polygon	114	federal lowcost3 tan2	commercial	motopark/shops	high

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ArcView GIS 3.2a

File Edit Table Field XTools Window Help

0 of 134 selected

Attributes of Commercial shape1.shp

Shape	ID	Ld_use_Area(layout)	Ld_use_Type	Ld_use_Status	Ld_use_Popdsty
Polygon	97	area L1	commercial	shops	medium
Polygon	98	area L2	commercial	shops	medium
Polygon	99	area L3	commercial	shops	medium
Polygon	100	area L4	commercial	shops	medium
Polygon	101	area L5	commercial	shops	medium
Polygon	102	area M	commercial	worldbank mkt	high
Polygon	103	area M1	commercial	shops	medium
Polygon	104	area M2	commercial	shops	medium
Polygon	105	area M3	commercial	shops	medium
Polygon	106	area M4	commercial	shops	medium
Polygon	107	area M5	commercial	shops	medium
Polygon	108	area M6	commercial	shops	medium
Polygon	109	area M7	commercial	shops	medium
Polygon	110	area M8	commercial	shops	medium
Polygon	111	federal lowcost tan2	commercial	shops	medium
Polygon	112	federal lowcost1 tan2	commercial	shops	medium
Polygon	113	federal lowcost2 tan2	commercial	shops	medium
Polygon	114	federal lowcost3 tan2	commercial	motopark/shops	high
Polygon	115	federal lowcost4tan2	commercial	corner shops	medium
Polygon	116	area S	commercial	activity centre	high
Polygon	117	area S1	commercial	parking bay	high
Polygon	118	area S2	commercial	shops	medium
Polygon	119	area X	commercial	shops	medium
Polygon	120	area X1	commercial	shops	medium
Polygon	121	area X2	commercial	shops	medium
Polygon	122	area X3	commercial	shops	medium
Polygon	123	new D	commercial	activity centre	
Polygon	124	new D1	commercial	market	high
Polygon	125	area Y	commercial	market	high
Polygon	126	area Y1	commercial	shops	medium
Polygon	127	area Y2	commercial	shops	medium
Polygon	128	exhibition1	commercial	open space	
Polygon	129	industrial24	commercial	open space	
Polygon	130	industrial25	commercial	open space	
Polygon	131	industrial26	commercial		medium
Polygon	132	industrial27	commercial		medium
Polygon	133	secretarait	commercial	central bank	high
Polygon	134	public building8	commercial	shops	medium

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Table 3.5 Attribute of public land use

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Attributes of Public shape1.shp

Shape	ID	Ld_use_Area(layout)	Ld_use_Type	Ld_use_Status	Ld_use-Popdsity
Polygon	1	amakaohia pocket	public use	vet clinic	medium
Polygon	2	arugo	public use	alvan sec school	high
Polygon	3	arugo1	public use	alvan extention	high
Polygon	4	arugo2	public use	public plots	medium
Polygon	5	arugo3	public use	public plots	medium
Polygon	6	ekwemma residential	public use	holyhgost college	high
Polygon	7	public building	public use	imigration	medium
Polygon	8	public building1	public use	internal revenue	medium
Polygon	9	public building2	public use	fed min of information	high
Polygon	10	public building3	public use	fire station	low
Polygon	11	public building4	public use	public plots	medium
Polygon	12	public building5	public use	moto driving school	
Polygon	13	public building6	public use	reserve	low
Polygon	14	public building7	public use	H P Udoh	low
Polygon	15	public building8	public use	reserve for hospital	high
Polygon	16	public building9	public use	nepa/fed dev centre	high
Polygon	17	public building10	public use	federal ministries	high
Polygon	18	public building11	public use	P&T training school	medium
Polygon	19	public building12	public use	reserve	low
Polygon	20	public building13	public use	sports	high
Polygon	21	public building14	public use	club	high
Polygon	22	public building15	public use	staff dev centre	medium
Polygon	23	public building16	public use	coperative colege site	high
Polygon	24	new owerri south	public use	reserve/health centre	medium
Polygon	25	new owerri south1	public use	reserve	low
Polygon	26	new owerri south2	public use	open space	zero
Polygon	27	new owerri south3	public use	farmland	low
Polygon	28	new owerri south4	public use	farmland	low
Polygon	29	new owerri south5	public use	ministry of agric	medium
Polygon	30	new owerri south6	public use	vet clinic	high
Polygon	31	new owerri south7	public use	fish pond	low
Polygon	32	new owerri south8	public use	garden	low
Polygon	33	new owerri south9	public use	reserve	low
Polygon	34	new owerri south10	public use	zoo area	low
Polygon	35	new owerri south11	public use	model farm	low
Polygon	36	new owerri south12	public use	farm extention	low
Polygon	37	new owerri south13	public use	reserve	low
Polygon	38	new owerri south14	public use	health centre	medium

ArcView GIS 3.2a

Attributes of Public shape1.shp

Shape	ID	Ld_use_Area(layout)	Ld_use_Type	Ld_use_Status	Ld_use-Popdsity
Polygon	39	new owerri south15	public use	reserve	low
Polygon	40	new owerri south16	public use	sec school	high
Polygon	41	new owerri south17	public use	club	high
Polygon	42	new owerri south18	public use	sports	high
Polygon	43	new owerri south19	public use	public plots	low
Polygon	44	new owerri east	public use	open theathre	medium
Polygon	45	new owerri east1	public use	open space	zero
Polygon	46	new owerri east2	public use	zoo area	low
Polygon	47	new owerri east3	public use	zoo extention	low
Polygon	48	new owerri east4	public use	reserve	low
Polygon	49	new owerri 5	public use	golf course	low
Polygon	50	area F	public use	public plots	low
Polygon	51	area F1	public use	church	high
Polygon	52	area G	public use	health centre	medium
Polygon	53	area G1	public use	church	high
Polygon	54	area G2	public use	health clinic	medium
Polygon	55	area E	public use	nursery school	medium
Polygon	56	area B	public use	primary school	high
Polygon	57	area B1	public use	health centre	medium
Polygon	58	area H	public use	primary school	high
Polygon	59	area H1	public use	secondary school	high
Polygon	60	area P	public use	primary school	high
Polygon	61	area P1	public use	primary & sec school	high
Polygon	62	area R	public use	helt centre &prim schoo	high
Polygon	63	area V	public use	health centre	medium
Polygon	64	area V1	public use	primary school	high
Polygon	65	area T'M	public use	prim, sec sch &helt cen	high
Polygon	66	area T'N	public use	secondary school	high
Polygon	67	exhibition	public use	exhibition ground	medium
Polygon	68	secretarait extention	public use	federal secretarait	high
Polygon	69	secretarait extention1	public use	inec,office &court	high
Polygon	70	state secretarait	public use	state secretarait	high
Polygon	71	state secretarait1	public use	public plots	low
Polygon	72	capitol area	public use	public plots	low
Polygon	73	capitol area1	public use	cultural centre	medium
Polygon	74	capitol area2	public use	public plots	low
Polygon	75	capitol area3	public use	public plots	low
Polygon	76	capitol area4	public use	public plots	low

ArcView GIS 3.2a

File Edit Table Field XTools Window Help

0 of 160 selected

Attributes of Public shape1.shp

Shape	ID	Id_use_Area(layout)	Ld_use_Type	Ld_use_Status	Ld_use-Popdsity
Polygon	77	capitol area5	public use	public plots	low
Polygon	78	capitol area6	public use	public plots	low
Polygon	79	capitol area7	public use	public plots	low
Polygon	80	capitol area8	public use	public plots	low
Polygon	81	civic centre	public use	stadium, sports hall	high
Polygon	82	civic centre1	public use	cinema & open space	high
Polygon	83	civic centre	public use	ltv, Nta offices	medium
Polygon	84	capitol area9	public use	house of assembley	low
Polygon	85	capitol area10	public use	public plots	low
Polygon	86	capitol area11	public use	open space	zero
Polygon	87	onitsha/youths	public use	owerri girls	high
Polygon	88	onitsha/youths1	public use	assumpta cathedral	high
Polygon	89	onitsha/youths2	public use	nafdag	medium
Polygon	90	area D	vpublic use	nursery school	high
Polygon	91	onitsha/youths3	public use	ministr of petroleum	medium
Polygon	92	area D1	public use	nursery school	medium
Polygon	93	area D2	public use	winners church	high
Polygon	94	amakohia pocket1	public use	police school	high
Polygon	95	arugo4	public use	public plots	low
Polygon	96	arugo5	public use	public plots	low
Polygon	97	onitsha/youths4	public use	rochas sec school	high
Polygon	98	onitsha/youths5	public use	primary school	high
Polygon	99	onitsha/youths6	public use	health centre	high
Polygon	100	onitsha/youths7	public use	niger hospital	high
Polygon	101	new owerri south20	public use	prison healthquarters	high
Polygon	102	area D3	public use	nddc	high
Polygon	103	new owerri east5	public use	country club	high
Polygon	104	area A	public use	health centre &church	high
Polygon	105	area A1	public use	secondary school	high
Polygon	106	area N	public use	prim &sec school	high
Polygon	107	area N1	public use	anglican church	high
Polygon	108	capitol area12	public use	public house	low
Polygon	109	federal lowcost tan1	public use	st marks cath church	high
Polygon	110	federal lowcost1tan1	public use	secondary school	high
Polygon	111	new owerri south21	public use	remand home/church	high
Polygon	112	new owerri south22	public use	cemetory south	low
Polygon	113	new owerri south23	public use	cemetory smith	low
Polygon	114	area E	public use	secondary school	high

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ArcView GIS 3.2a

File Edit Table Field XTools Window Help

0 of 160 selected

Attributes of Public shape1.shp

Shape	ID	Id_use_Area(layout)	Ld_use_Type	Ld_use_Status	Ld_use-Popdsity
Polygon	115	area L	public use	assemble of God	high
Polygon	116	area L1	public use	prim & sec school	high
Polygon	117	area M	public use	health centre	high
Polygon	118	area M1	public use	methodist church	high
Polygon	119	public building	public use	general hospital	high
Polygon	120	federal lowcost tan2	public use	anglican church	high
Polygon	121	federal lowcost1 tan2	public use	post offic &helt centre	high
Polygon	122	federal lowcost2 tan2	public use	nursery school	high
Polygon	123	area S	public use	nursery &primary school	high
Polygon	124	area X	public use	prim & sec school	high
Polygon	125	area X1	public use	health centre	high
Polygon	126	public building17	public use	reserve	low
Polygon	127	public building18	public use	reserve army	low
Polygon	128	new D	public use	primary & sec school	high
Polygon	129	new D1	public use	health centre	high
Polygon	130	area Y	public use	primary school	high
Polygon	131	public building19	public use	open space	zero
Polygon	132	public building20	public use	open space	zero
Polygon	133	new owerri south24	public use	open space	zero
Polygon	134	new owerri south25	public use	open space	zero
Polygon	135	new owerri south26	public use	open space	zero
Polygon	136	new owerri south27	public use	open space	zero
Polygon	137	new owerri south28	public use	reserve	low
Polygon	138	new owerri south29	public use	open space	zero
Polygon	139	new owerri south30	public use	open space	zero
Polygon	140	new owerri south31	public use	nekede farm	low
Polygon	141	new owerri south32	public use	livestok scheme	low
Polygon	142	new owerri east5	public use	open space	zero
Polygon	143	new owerri east6	public use	open space	zero
Polygon	144	new owerri east7	public use	open space	zero
Polygon	145	amakohia pocket	public use	open space	zero
Polygon	146	arugo6	public use	open space	zero
Polygon	147	amakohia pocket3	public use	polic mibile force	medium
Polygon	148	public building21	public use	M O W &T	medium
Polygon	149	new owerri south33	public use	F M W H &serves schemes	high
Polygon	150	new owerri south34	public use	F M W H &serves schemes	high
Polygon	151	area D4	public use	judicary,jonalist &agri	high
Polygon	152	commercial district	public use	polic head quarters	high

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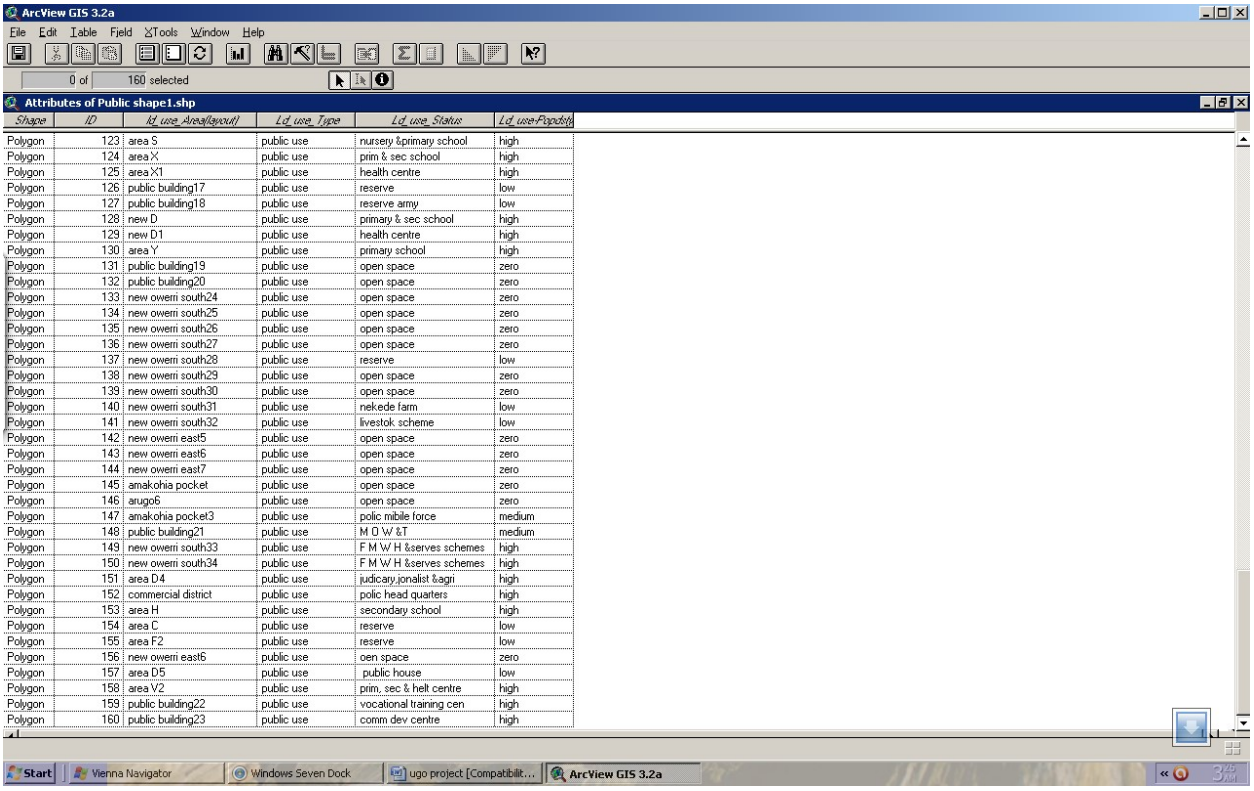

ArcView GIS 3.2a

File Edit Table Field XTools Window Help

0 of 160 selected

Attributes of Public shape1.shp

Shape	ID	Id_use_Area(layout)	Ld_use_Type	Ld_use_Status	Ld_use+Popdsity
Polygon	123	area S	public use	nursery &primary school	high
Polygon	124	area X	public use	prim & sec school	high
Polygon	125	area X1	public use	health centre	high
Polygon	126	public building17	public use	reserve	low
Polygon	127	public building18	public use	reserve army	low
Polygon	128	new D	public use	primary & sec school	high
Polygon	129	new D1	public use	health centre	high
Polygon	130	area Y	public use	primary school	high
Polygon	131	public building19	public use	open space	zero
Polygon	132	public building20	public use	open space	zero
Polygon	133	new owerri south24	public use	open space	zero
Polygon	134	new owerri south25	public use	open space	zero
Polygon	135	new owerri south26	public use	open space	zero
Polygon	136	new owerri south27	public use	open space	zero
Polygon	137	new owerri south28	public use	reserve	low
Polygon	138	new owerri south29	public use	open space	zero
Polygon	139	new owerri south30	public use	open space	zero
Polygon	140	new owerri south31	public use	nekede farm	low
Polygon	141	new owerri south32	public use	livestok scheme	low
Polygon	142	new owerri east5	public use	open space	zero
Polygon	143	new owerri east6	public use	open space	zero
Polygon	144	new owerri east7	public use	open space	zero
Polygon	145	amakohia pocket	public use	open space	zero
Polygon	146	arugo6	public use	open space	zero
Polygon	147	amakohia pocket3	public use	polic mibile force	medium
Polygon	148	public building21	public use	M O W &T	medium
Polygon	149	new owerri south33	public use	F M W H &serves schemes	high
Polygon	150	new owerri south34	public use	F M W H &serves schemes	high
Polygon	151	area D4	public use	judicary,jonalist &agri	high
Polygon	152	commercial district	public use	polic head quarters	high
Polygon	153	area H	public use	secondary school	high
Polygon	154	area C	public use	reserve	low
Polygon	155	area F2	public use	reserve	low
Polygon	156	new owerri east6	public use	oen space	zero
Polygon	157	area D5	public use	public house	low
Polygon	158	area V2	public use	prim, sec & helt centre	high
Polygon	159	public building22	public use	vocational training cen	high
Polygon	160	public building23	public use	comm dev centre	high

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Table3.6 Attribute table for roads

ArcView GIS 3.2a

File Edit Table Field XTools Window Help

0 of 112 selected

Attributes of Road shape1.shp

Shape	ID	Rd_Name	Rd_lLength	Rd_Type	Rd_Status
Polygon	1	onitsha road	3717.72	major	tared
Polygon	2	nworie drive	3350.47	major	tared
Polygon	3	old nek-ede road	1425.36	major	untared
Polygon	4	alvan extention road	855.38	minor	untared
Polygon	5	arugo internal road	1684.88	minor	untared
Polygon	6	arugo east road	1179.34	minor	untared
Polygon	7	mobile police road	1623.97	minor	untared
Polygon	8	NCT arterial highway	5472.60	major	tared
Polygon	9	SCT arterial highway	9031.90	major	tared
Polygon	10	SMT arterial highwa1	6121.19	major	tared
Polygon	11	ECT arterial highwa2	6150.19	major	tared
Polygon	12	ECT arterial highwa1	5253.99	major	tared
Polygon	13	WCT arterial highwa1	6755.14	major	tared
Polygon	14	WMT arterial highwa2	8504.27	major	tared
Polygon	15	train route road	8875.30	major	untared
Polygon	16	SET freeway	4551.09	major	tared
Polygon	17	WET freeway	7108.30	major	tared
Polygon	18	NET freeway	3599.06	major	tared
Polygon	19	portharcourt road	6386.07	major	tared
Polygon	20	industrial road1	1948.32	minor	tared
Polygon	21	industrial road3	1998.74	minor	tared
Polygon	22	industrial road4	1877.07	minor	tared
Polygon	23	east industrial road	1689.97	minor	untared
Polygon	24	public street road1	1022.36	minor	untared
Polygon	25	umuejechi village rd	424.24	minor	untared
Polygon	26	umugwule vilage rd	1320.45	minor	untared
Polygon	27	umumbazu vilage rd	1907.02	minor	untared
Polygon	28	avu junction road	2097.29	minor	untared
Polygon	29	remand home ext rd	1837.74	minor	untared
Polygon	30	area M internal rd1	1111.39	minor	untared
Polygon	31	area M internal rd2	808.04	minor	untared
Polygon	32	area M internal rd3	954.91	minor	untared
Polygon	33	area M/N joint road	1660.91	minor	untared
Polygon	34	area M internal rd1	973.92	minor	untared
Polygon	35	area M internal rd1	856.46	minor	untared
Polygon	36	area M internal rd1	1047.01	minor	untared
Polygon	37	onitsha/youth rd1	959.49	minor	untared
Polygon	38	federal LC tan2 rd1	990.09	minor	untared

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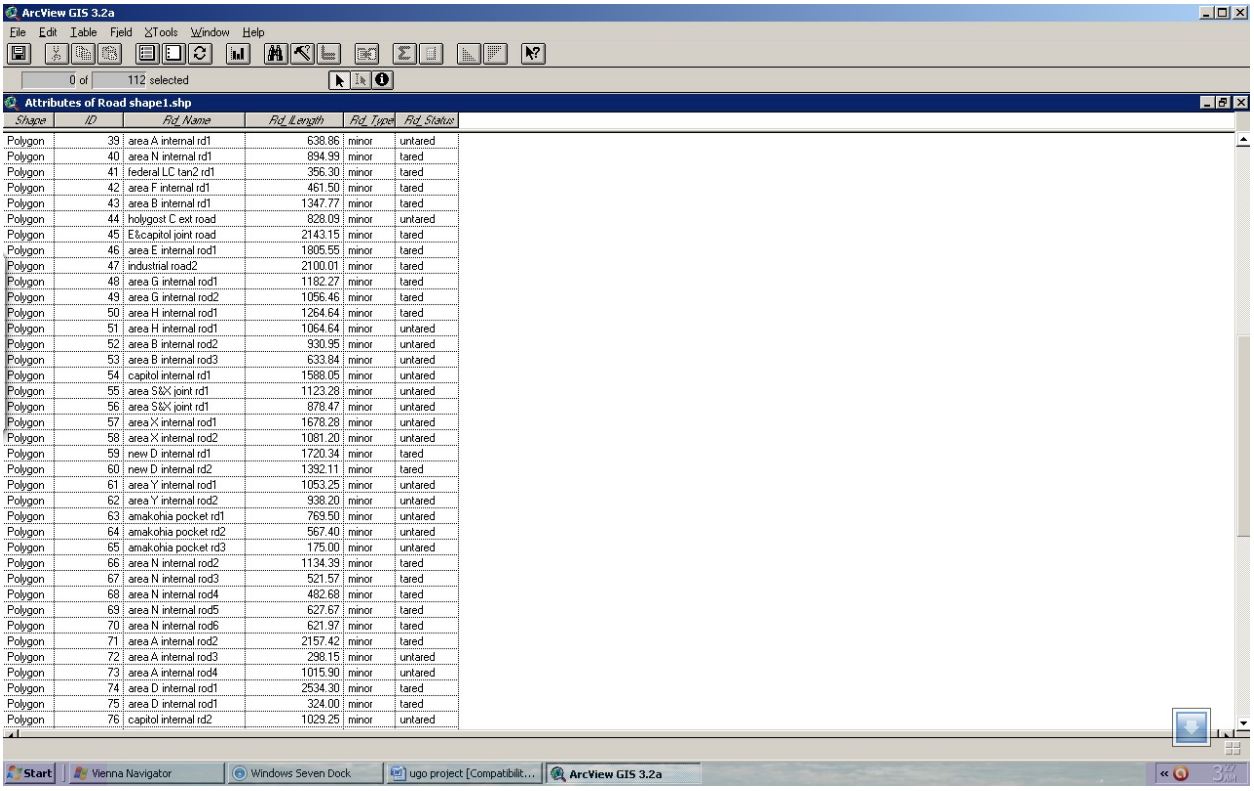

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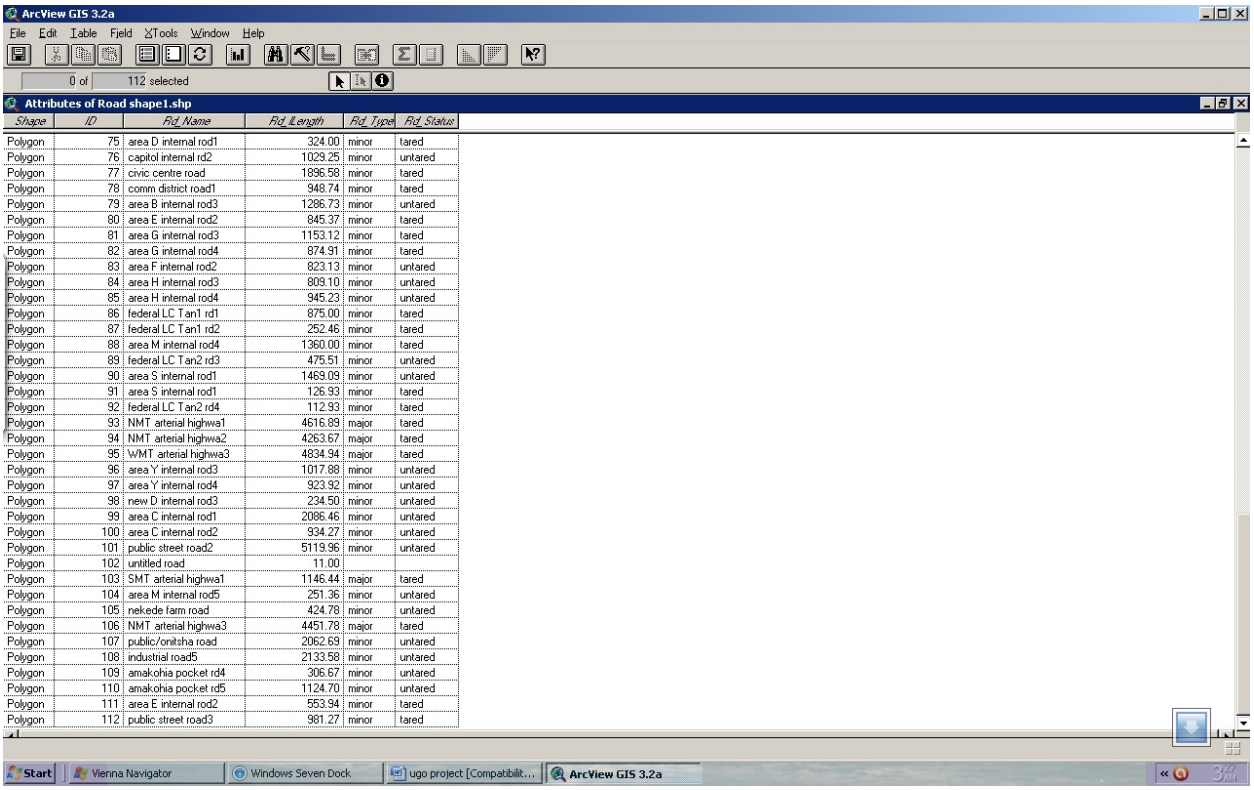
File Edit Table Field XTools Window Help

0 of 112 selected

Attributes of Road shape1.shp

Shape	ID	Rd_Name	Rd_lLength	Rd_Type	Rd_Status
Polygon	39	area A internal rd1	638.86	minor	untared
Polygon	40	area N internal rd1	894.99	minor	tared
Polygon	41	federal LC tan2 rd1	356.30	minor	tared
Polygon	42	area F internal rd1	461.50	minor	tared
Polygon	43	area B internal rd1	1347.77	minor	tared
Polygon	44	holygost C ext road	828.09	minor	untared
Polygon	45	E&capitol joint road	2143.15	minor	tared
Polygon	46	area E internal rod1	1805.55	minor	tared
Polygon	47	industrial road2	2100.01	minor	tared
Polygon	48	area G internal rod1	1182.27	minor	tared
Polygon	49	area G internal rod2	1056.46	minor	tared
Polygon	50	area H internal rod1	1264.64	minor	tared
Polygon	51	area H internal rod1	1064.64	minor	untared
Polygon	52	area B internal rod2	930.95	minor	untared
Polygon	53	area B internal rod3	633.84	minor	untared
Polygon	54	capitol internal rd1	1588.05	minor	untared
Polygon	55	area S&X joint rd1	1123.28	minor	untared
Polygon	56	area S&X joint rd1	878.47	minor	untared
Polygon	57	area X internal rod1	1678.28	minor	untared
Polygon	58	area X internal rod2	1081.20	minor	untared
Polygon	59	new D internal rd1	1720.34	minor	tared
Polygon	60	new D internal rd2	1392.11	minor	tared
Polygon	61	area Y internal rod1	1053.25	minor	untared
Polygon	62	area Y internal rod2	938.20	minor	untared
Polygon	63	amakohia pocket rd1	769.50	minor	untared
Polygon	64	amakohia pocket rd2	567.40	minor	untared
Polygon	65	amakohia pocket rd3	175.00	minor	untared
Polygon	66	area N internal rod2	1134.39	minor	tared
Polygon	67	area N internal rod3	521.57	minor	tared
Polygon	68	area N internal rod4	482.68	minor	tared
Polygon	69	area N internal rod5	627.67	minor	tared
Polygon	70	area N internal rod6	621.97	minor	tared
Polygon	71	area A internal rod2	2157.42	minor	tared
Polygon	72	area A internal rod3	298.15	minor	untared
Polygon	73	area A internal rod4	1015.90	minor	untared
Polygon	74	area D internal rod1	2534.30	minor	tared
Polygon	75	area D internal rod1	324.00	minor	tared
Polygon	76	capitol internal rd2	1029.25	minor	untared

Start | Vienna Navigator | Windows Seven Dock | ugo project [Compatibilit... | ArcView GIS 3.2a



ArcView GIS 3.2a

File Edit Table Field XTools Window Help

0 of 112 selected

Attributes of Road shape1.shp

Shape	ID	Rd_Name	Rd_lLength	Rd_Type	Rd_Status
Polygon	75	area D internal rod1	324.00	minor	tared
Polygon	76	capitol internal rd2	1029.25	minor	untared
Polygon	77	civic centre road	1896.58	minor	tared
Polygon	78	comm district road1	948.74	minor	tared
Polygon	79	area B internal rod3	1286.73	minor	untared
Polygon	80	area E internal rod2	845.37	minor	tared
Polygon	81	area G internal rod3	1153.12	minor	tared
Polygon	82	area G internal rod4	874.91	minor	tared
Polygon	83	area F internal rod2	823.13	minor	untared
Polygon	84	area H internal rod3	809.10	minor	untared
Polygon	85	area H internal rod4	945.23	minor	untared
Polygon	86	federal LC Tan1 rd1	875.00	minor	tared
Polygon	87	federal LC Tan1 rd2	252.46	minor	tared
Polygon	88	area M internal rod4	1360.00	minor	tared
Polygon	89	federal LC Tan2 rd3	475.51	minor	untared
Polygon	90	area S internal rod1	1469.09	minor	untared
Polygon	91	area S internal rod1	126.93	minor	tared
Polygon	92	federal LC Tan2 rd4	112.93	minor	tared
Polygon	93	NMT arterial highwa1	4616.89	major	tared
Polygon	94	NMT arterial highwa2	4263.67	major	tared
Polygon	95	WMT arterial highwa3	4834.94	major	tared
Polygon	96	area Y internal rod3	1017.88	minor	untared
Polygon	97	area Y internal rod4	923.92	minor	untared
Polygon	98	new D internal rod3	234.50	minor	untared
Polygon	99	area C internal rod1	2086.46	minor	untared
Polygon	100	area C internal rod2	934.27	minor	untared
Polygon	101	public street road2	5119.96	minor	untared
Polygon	102	untitled road	11.00		
Polygon	103	SMT arterial highwa1	1146.44	major	tared
Polygon	104	area M internal rod5	251.36	minor	untared
Polygon	105	nekede farm road	424.78	minor	untared
Polygon	106	NMT arterial highwa3	4451.78	major	tared
Polygon	107	public/onitsha road	2062.69	minor	untared
Polygon	108	industrial road5	2133.58	minor	untared
Polygon	109	amakohia pocket rd4	306.67	minor	untared
Polygon	110	amakohia pocket rd5	1124.70	minor	untared
Polygon	111	area E internal rod2	553.94	minor	tared
Polygon	112	public street road3	981.27	minor	tared

Start | Vienna Navigator | Windows Seven Dock | ugo project [Compatibilit... | ArcView GIS 3.2a

Table 3.7 Attribute table for river

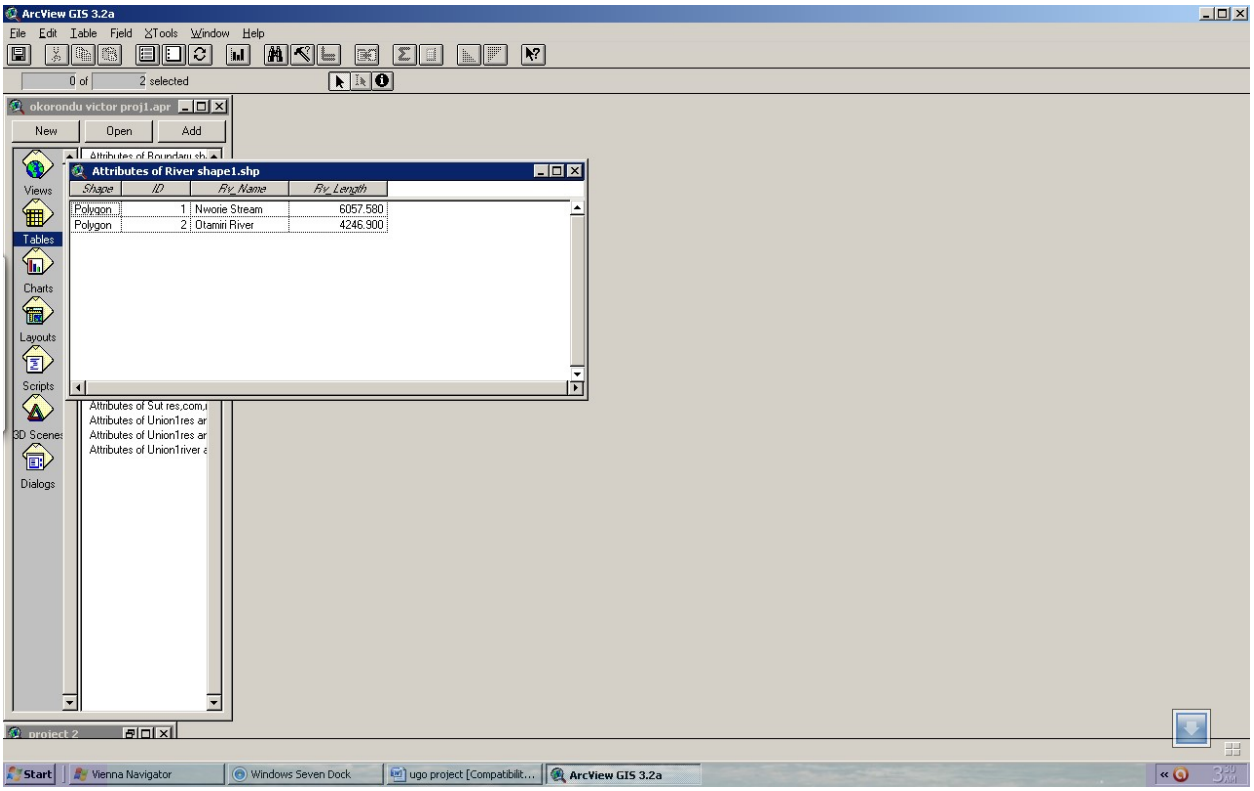


Table 3.8 Attribute table for residential land use

ArcView GIS 3.2a

File Edit Table Field XTools Window Help

0 of 251 selected

Attributes of Residential shape1.shp

Shape	ID	Ld_use Area(layout)	Ld_use Type	Ld_use Status	Ld_use Popdsty
Polygon	1	amakohia pocket	residential	duplexes	medium
Polygon	2	amakohia pocket1	residential	duplexes	medium
Polygon	3	amakohia pocket2	residential	duplexes	medium
Polygon	4	amakohia pocket3	residential	duplexes	medium
Polygon	5	amakohia pocket3	residential	duplexes	medium
Polygon	6	amakohia pocket4	residential	duplexes	medium
Polygon	7	amakohia pocket5	residential	duplexes	medium
Polygon	8	arugo	residential	duplexes	medium
Polygon	9	onitsha/youth centre	residential	duplexes	medium
Polygon	10	umumbazu village1	residential	bungalows	high
Polygon	11	umujechi village	residential	bungalows	high
Polygon	12	umugwule village	residential	bungalows	high
Polygon	13	umumbazu village2	residential	bungalows	high
Polygon	14	area F	residential	duplexes	medium
Polygon	15	area F1	residential	duplexes	high
Polygon	16	area F2	residential	duplexes	medium
Polygon	17	area F3	residential	duplexes	medium
Polygon	18	area F4	residential	duplexes	medium
Polygon	19	area F5	residential	duplexes	medium
Polygon	20	areaG19	residential	CEO duplex	medium
Polygon	21	area G	residential	duplexes	medium
Polygon	22	area G1	residential	duplexes	medium
Polygon	23	area G2	residential	duplexes	medium
Polygon	24	area G3	residential	duplexes	medium
Polygon	25	area G4	residential	duplexes	medium
Polygon	26	area G5	residential	open space	zero
Polygon	27	area G6	residential	duplexes	medium
Polygon	28	area G7	residential	duplexes	medium
Polygon	29	area G8	residential	duplexes	medium
Polygon	30	area G9	residential	open space	zero
Polygon	31	area G10	residential	duplexes	medium
Polygon	32	area G11	residential	duplexes	medium
Polygon	33	area G12	residential	duplexes	medium
Polygon	34	area G13	residential	duplexes	medium
Polygon	35	area G14	residential	duplexes	medium
Polygon	36	area G15	residential	duplexes	medium
Polygon	37	area G16	residential	duplexes	medium
Polygon	38	area G17	residential	CEO duplex	medium

Start | Vienna Navigator | Windows Seven Dock | ugo project [Compatibilit... | ArcView GIS 3.2a

ArcView GIS 3.2a

File Edit Table Field XTools Window Help

0 of 251 selected

Attributes of Residential shape1.shp

Shape	ID	Ld_use Area(layout)	Ld_use Type	Ld_use Status	Ld_use Popdsty
Polygon	39	area G18	residential	duplexes	medium
Polygon	40	area C	residential	duplexes	medium
Polygon	41	area C1	residential	duplexes	medium
Polygon	42	area C2	residential	duplexes	medium
Polygon	43	area C3	residential	duplexes	medium
Polygon	44	area C4	residential	duplexes	medium
Polygon	45	area C5	residential	duplexes	medium
Polygon	46	area C6	residential	duplexes	medium
Polygon	47	area E	residential	open space	zero
Polygon	48	area E1	residential	open space	zero
Polygon	49	area E2	residential	open space	zero
Polygon	50	area E3	residential	duplexes	medium
Polygon	51	area E4	residential	duplexes	medium
Polygon	52	area E5	residential	duplexes	medium
Polygon	53	area E5	residential	duplexes	medium
Polygon	54	area E6	residential	duplexes	medium
Polygon	55	area E7	residential	duplexes	medium
Polygon	56	area E8	residential	duplexes	medium
Polygon	57	area E9	residential	duplexes	medium
Polygon	58	area E10	residential	duplexes	medium
Polygon	59	area E11	residential	open space	zero
Polygon	60	area B	residential	open space	zero
Polygon	61	area B1	residential	duplexes	medium
Polygon	62	area B2	residential	duplexes	medium
Polygon	63	area B3	residential	duplexes	medium
Polygon	64	area B4	residential	duplexes	medium
Polygon	65	area B5	residential	duplexes	medium
Polygon	66	area B6	residential	duplexes	medium
Polygon	67	area B7	residential	duplexes	medium
Polygon	68	area B8	residential	duplexes	medium
Polygon	69	area B9	residential	duplexes	medium
Polygon	70	area B10	residential	duplexes	medium
Polygon	71	area B11	residential	duplexes	medium
Polygon	72	area B12	residential	duplexes	medium
Polygon	73	area B13	residential	duplexes	medium
Polygon	74	area B14	residential	duplexes	medium
Polygon	75	area B15	residential	duplexes	medium
Polygon	76	area H	residential	duplexes	medium

Start | Vienna Navigator | Windows Seven Dock | ugo project [Compatibilit... | ArcView GIS 3.2a

ArcView GIS 3.2a

File Edit Table Field XTools Window Help

0 of 251 selected

Attributes of Residential shape1.shp

Shape	ID	Ld_use Area(layout)	Ld_use Type	Ld_use Status	Ld_use Popdsity
Polygon	77	area H1	residential	duplexes	medium
Polygon	78	area H2	residential	duplexes	medium
Polygon	79	area H3	residential	duplexes	medium
Polygon	80	area H4	residential	duplexes	medium
Polygon	81	area H5	residential	duplexes	medium
Polygon	82	area H6	residential	duplexes	medium
Polygon	83	area H7	residential	duplexes	medium
Polygon	84	area H8	residential	duplexes	medium
Polygon	85	area H9	residential	duplexes	medium
Polygon	86	area H10	residential	duplexes	medium
Polygon	87	area H11	residential	duplexes	medium
Polygon	88	area P	residential	duplexes	medium
Polygon	89	area R	residential	duplexes	medium
Polygon	90	area U'A	residential	duplexes	medium
Polygon	91	area T'A	residential	duplexes	medium
Polygon	92	area T	residential	duplexes	medium
Polygon	93	area U	residential	duplexes	medium
Polygon	94	area W	residential	duplexes	medium
Polygon	95	area W1	residential	duplexes	medium
Polygon	96	area T'M	residential	duplexes	medium
Polygon	97	area T'N	residential	duplexes	medium
Polygon	98	area D	residential	duplexes	medium
Polygon	99	area D1	residentialvresi	duplexes	medium
Polygon	100	area D2	residential	duplexes	medium
Polygon	101	area D3	residential	duplexes	medium
Polygon	102	area D4	residential	duplexes	medium
Polygon	103	area K	residential	bungalows	high
Polygon	104	area K1	residential	bungalows	high
Polygon	105	area D5	residential	duplexes	medium
Polygon	106	onitsha/youth centre	residential	duplexes	medium
Polygon	107	onitsha/youth centre1	residential	duplexes	medium
Polygon	108	onitsha/youth centre2	residential	duplexes	medium
Polygon	109	onitsha/youth centre3	residential	duplexes	medium
Polygon	110	onitsha/youth centre4	residential	duplexes	medium
Polygon	111	onitsha/youth centre5	residential	duplexes	medium
Polygon	112	onitsha/youth centre6	residential	duplexes	medium
Polygon	113	area A	residential	duplexes	medium
Polygon	114	area A1	residential	duplexes	medium

Start | Vienna Navigator | Windows Seven Dock | ugo project [Compatibilit... | ArcView GIS 3.2a

ArcView GIS 3.2a

File Edit Table Field XTools Window Help

0 of 251 selected

Attributes of Residential shape1.shp

Shape	ID	Ld_use Area(layout)	Ld_use Type	Ld_use Status	Ld_use Popdsity
Polygon	115	area A2	residential	duplexes	medium
Polygon	116	area A3	residential	duplexes	medium
Polygon	117	area A4	residential	duplexes	medium
Polygon	118	area A5	residential	duplexes	medium
Polygon	119	area A6	residential	duplexes	medium
Polygon	120	area A7	residential	duplexes	medium
Polygon	121	area A8	residential	duplexes	medium
Polygon	122	area A9	residential	duplexes	medium
Polygon	123	area A10	residential	duplexes	medium
Polygon	124	area A11	residential	duplexes	medium
Polygon	125	area A12	residential	open space	zero
Polygon	126	area A13	residential	open space	zero
Polygon	127	area N	residential	bungalows	high
Polygon	128	area N1	residential	bungalows	high
Polygon	129	area N2	residential	bungalows	high
Polygon	130	area N3	residential	bungalows	high
Polygon	131	area N4	residential	bungalows	high
Polygon	132	area N5	residential	bungalows	high
Polygon	133	area N6	residential	bungalows	high
Polygon	134	area N7	residential	bungalows	high
Polygon	135	area N8	residential	bungalows	high
Polygon	136	area N9	residential	bungalows	high
Polygon	137	area N10	residential	bungalows	high
Polygon	138	area N11	residential	bungalows	high
Polygon	139	area D3	residential	open space	zero
Polygon	140	area B16	residential	duplexes	high
Polygon	141	area H12	residential	duplexes	high
Polygon	142	federal LC1 Tan1	residential	bungalows	high
Polygon	143	federal LC2 Tan1	residential	bungalows	high
Polygon	144	federal LC3 Tan1	residential	bungalows	high
Polygon	145	federal LC4 Tan1	residential	bungalows	high
Polygon	146	federal LC5 Tan1	residential	bungalows	high
Polygon	147	area L	residential	bungalows	high
Polygon	148	area L1	residential	bungalows	high
Polygon	149	area L2	residential	bungalows	high
Polygon	150	area L3	residential	bungalows	high
Polygon	151	area L4	residential	bungalows	high
Polygon	152	area L5	residential	bungalows	high

Start | Vienna Navigator | Windows Seven Dock | ugo project [Compatibilit... | ArcView GIS 3.2a

ArcView GIS 3.2a

File Edit Table Field XTools Window Help

0 of 251 selected

Attributes of Residential shape1.shp

Shape	ID	Ld_use Area(layout)	Ld_use Type	Ld_use Status	Ld_use Popdsity
Polygon	153	area L5	residential	bungalows	high
Polygon	154	area L6	residential	bungalows	high
Polygon	155	area L7	residential	bungalows	highv
Polygon	156	area L8	residential	bungalows	high
Polygon	157	area M	residential	bungalows	high
Polygon	158	area M1	residential	open space	zero
Polygon	159	area M2	residential	bungalows	high
Polygon	160	area M3	residential	bungalows	high
Polygon	161	area M4	residential	bungalows	high
Polygon	162	area M4	residential	bungalows	high
Polygon	163	area M6	residential	bungalows	high
Polygon	164	area M7	residential	bungalows	high
Polygon	165	area M8	residential	bungalows	high
Polygon	166	area M9	residential	open space	zero
Polygon	167	area M10	residential	bungalows	high
Polygon	168	area M11	residential	bungalows	high
Polygon	169	public building	residential	bungalows	high
Polygon	170	federal LC Tan2	residential	open space	zero
Polygon	171	federal LC1 Tan2	residential	bungalows	high
Polygon	172	federal LC2 Tan2	residential	bungalows	high
Polygon	173	federal LC3 Tan2	residential	bungalows	high
Polygon	174	federal LC4 Tan2	residential	bungalows	high
Polygon	175	federal LC5 Tan2	residential	bungalows	high
Polygon	176	federal LC6 Tan2	residential	bungalows	high
Polygon	177	federal LC7 Tan2	residential	bungalows	high
Polygon	178	federal LC8Tan2	residential	bungalows	high
Polygon	179	federal LC9 Tan2	residential	bungalows	high
Polygon	180	federal LC10 Tan2	residential	bungalows	high
Polygon	181	federal LC11Tan2	residential	bungalows	high
Polygon	182	federal LC12Tan2	residential	bungalows	high
Polygon	183	area S	residential	open space	zero
Polygon	184	area S1	residential	duplexes	medium
Polygon	185	area S2	residential	duplexes	medium
Polygon	186	area S3	residential	duplexes	medium
Polygon	187	area S4	residential	duplexes	medium
Polygon	188	area S5	residential	bungalows	high
Polygon	189	area S6	residential	bungalows	high
Polygon	190	area S7	residential	bungalows	high

Start | Vienna Navigator | Windows Seven Dock | ugo project [Compatibilit... | ArcView GIS 3.2a

ArcView GIS 3.2a

File Edit Table Field XTools Window Help

0 of 251 selected

Attributes of Residential shape1.shp

Shape	ID	Ld_use Area(layout)	Ld_use Type	Ld_use Status	Ld_use Popdsity
Polygon	191	area S8	residential	bungalows	high
Polygon	192	area S9	residential	bungalows	high
Polygon	193	area X	residential	open space	zero
Polygon	194	area X1	residential	duplexes	medium
Polygon	195	area X2	residential	duplexes	medium
Polygon	196	area X3	residential	duplexes	medium
Polygon	197	area X4	residential	open space	zero
Polygon	198	area X5	residential	bungalows	high
Polygon	199	area X6	residential	duplexes	medium
Polygon	200	area X7	residential	duplexes	medium
Polygon	201	area X8	residential	duplexes	medium
Polygon	202	area X9	residential	duplexes	medium
Polygon	203	area X10	residential	open space	zero
Polygon	204	area X11	residential	duplexes	medium
Polygon	205	area X12	residential	duplexes	medium
Polygon	206	area X13	residential	duplexes	medium
Polygon	207	area X14	residential	open space	zero
Polygon	208	area X15	residential	duplexes	medium
Polygon	209	area X16	residential	duplexes	medium
Polygon	210	area X17	residential	duplexes	medium
Polygon	211	area X18	residential	duplexes	medium
Polygon	212	area X19	residential	duplexes	medium
Polygon	213	area X20	residential	duplexes	medium
Polygon	214	area X21	residential	duplexes	medium
Polygon	215	area X22	residential	duplexes	medium
Polygon	216	area X23	residential	duplexes	medium
Polygon	217	area X24	residential	open space	zero
Polygon	218	area Y	residential	open space	zero
Polygon	219	area Y1	residential	duplexes	medium
Polygon	220	area Y2	residential	duplexes	medium
Polygon	221	area Y3	residential	duplexes	medium
Polygon	222	area Y4	residential	duplexes	medium
Polygon	223	area Y5	residential	duplexes	medium
Polygon	224	area Y6	residential	duplexes	medium
Polygon	225	area Y6	residential	duplexes	medium
Polygon	226	area Y7	residential	duplexes	medium
Polygon	227	area Y8	residential	duplexes	medium
Polygon	228	area Y9	residential	duplexes	medium

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