REMOTE SENSING APPLICATION IN MILITARY TERRAIN FOR FOOT INFANTRY TRAFFICABILITY IN JAJI, KADUNA STATE, NIGERIA

BY

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DECLARATION

I hereby declare that this research project has been carried out by me under the supervision of Prof G.N. Nsofor of the Department of Geography, Federal University of Technology, Minna, Niger State.

Stephen D. Norman

Sign:.......................................

Date: 12 August 2017

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There is always a reward for hard work, perseverance and steadfastness, and I consider it is a privilege from Almighty God that, I am able to put together this dissertation.

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ABSTRACT

Observations from the current trends in wars show that threat to a nation can be from external or internal forces. It becomes essential for the army formation to understand the environment in where the battle will be fought whether within or outside its territory. One of the major problems facing military operation that determines the success of a nation in war combat is the ability of the troops in question to understand how to move in the battle ground.

There is the need to give an appropriate training to military force even before the challenges of war come closer. The word "Appropriate Training" must be given a kin observation because it has to do with where and how it is being given. Based on this, a training ground needs to be analyzed weather it can serve the purpose of preparing the army "appropriately" for the task ahead.

The aim of the research is to examine the appropriateness of Jaji Military ground for multi purpose training and exercise using Remote Sensing techniques. The aim was followed by four objectives, they are mapping the entire study area, physical landscape identification, classification of identified landscape attributes and the determination capability of each land unit identified for specific military operation. To achieve the stated aim and objectives, there is need to use Remote Sensing data since there is no existing base map of the study area. The suitable available data was satellite image (SPOT XS). This was collected and an appropriate processing was carried out to help the extraction of useful information.

The major analyses carried out were local government enhancement, linear stretching and colour composite for proper identification of surface feature

for study and mapping. Together with this satellite image, a field survey was carried out to get the spot height with Global Positioning System (GPS).

The GPS data were used for two major purposes that is, for image referencing and orientation, and location and height value for determination of landform of the study area.

The accessibility study carried out gave a favourable support to cross country mobility and trafficability. This was established through the road network possibly within Bush Exercise Area. Also the inter-visibility operation carried out gave an encouraging result It gives an intelligent measure toward the possibility of getting target object at a particular range distance.

War is not an incidence to be prayed for, but it can come as fact(s) in life. Therefore, for any battle, this research can be used as preparatory measure towards achieving success. It is a form of groundwork that facilitates battle strategic planning. The terrain nature of where the battle can come up can be modeled via this study. In Remote Sensing and GIS, data are the most valuable factor that facilitates adequate study with good result. The quality of data input is capitalized on the output (information). Current data capturing is needed for example. Satellite Images, Aerial Photo, Land Survey data and Cartographic data (Hard copy Maps) of high accuracy must be always available. Also, the available data need to be kept in secured place to avoid spoilage, error introduction, loss of data etc. since satellite images are the most effective data presently, different type of this image must be available for comparison, test of accuracy and analysis. If there are data availabilities e.g. for Soil strength measure, Quick – Bird image of high resolution (5meters resolution) will improve the study further.

TABLE OF CONTENT

CHAPTER ONE

CHAPTER TWO

CHAPTER THREE

CHAPTER FOUR

CHAPTER FIVE

LIST OF FIGURES

LIST OF TABLES

CHAPTER ONE

INTRODUCTION

1.0 Introduction

A wide range of human endeavour such as rural and urban development, agricultural activities, and military operations now require good knowledge of terrain evaluation in order to perform efficiently. It is also necessary for effective conservation of dwindling resources through good management practices and their efficient utilization.

In many developing countries, terrain information is hardly sought for most land use planning and management; yet, its availability can help avert environmental disasters. Terrain information has been used to predict a range of land use problems and has helped planners build remedial strategies to solve them. For example, land classification has proved very useful in the construction of new residential housing layouts, rural development and road network in NSW, Austrialia (Hannam and Hicks, 1980). While developed countries have utilized terrain information schemes to improve their rural and urban developments. Nigeria is a country with a wide range of geological structures, soils, vegetations and hydro-meterological conditions. Variations in these environmental elements conditions can affect, negatively or positively, many socio-economic projects and activities. Hence, there is urgent need for establishment of land classification and terrain evaluation for a wide range of governmental and non-governmental land development activities (Young, 1975).

Over the past ninety years, the need for terrain analysis / evaluation for the benefits of the military have been on the increase. Emphasis is usually placed on the diggability and transversability of the land, for excavation and movement of both troops and vehicles (both tracked and untracked). Not only in military circle that the knowledge about terrain types becomes useful, but variety of disciplines with land utilization also makes use of terrain information concerning the worth of areas. The interest of the military in terrain evaluation is long standing history but recently expanded in response to the growing sophistication of modern weapons (Katsina, 19986). The basic approaches to military terrain evaluation have been developed and used world wide. The land system or Physiographic approach which considers the terrain itself classifying it into natural units and attempt to measure their properties quantitatively and relate them to land use possibilities. This approach which was developed by the British Military Engineering Experimental, Establishment, involves predicting terrain information by storing it according to generic units. The parametric approach tries to measure attributes of the landscape. This approach was developed by the

Canadian and U.S Armies and it involves the observation of the landscape at a network of sets, each of which is described in terms of its value according to some selected attributes (Mitchell, 1973).

Terrain Analysis means to determine or assess or express the value of a stretch of land with respect to its features or conditions, considered from a particular point of view most especially for tactical purposes (Cayne and Lechner, 1993). Terrain evaluation as a subject is an offspring of military campaigns on different types of terracing (Beckett and Webster, 1969; Mallo, 1995). The knowledge of the terrain is necessary because it forms, the bases for planning in terms of logistics, administrative and tactical planning in any military operation. Thus, land classification and evaluation for military operations in Nigeria are crucial, even though it is yet to receive official awareness and blessing; Military purposes for which terrain information is required include:

i. Tactical movement (of troops and vehicles, tracked and untracked);

ii. Concealment, from attack from both ground and air;

iii. Fortification of a particular position and;

iv. Availability of local supplies e.g. food, water, wood etc. (Ologe, 1990)

The rationale for military terrain analysis arises from the need to collect information about the terrain which can help to ensure the safety, security and general welfare of troops and so enhance their overall campaign performances. Besides, terrain analysis for the military can be used to determine the position and probable movement of the adversary (the enemy). Thus, in this study the purpose is to classify terrain into distinctive and recognizable units in accordance with military requirements.

1.1 Statement of Research Problem

Military interest in terrain evaluation can be understood when viewed from military activities ranging from lines of sight, instability of ground for excavation of trenches, erecting fortification, holding tent peg, accepting parachute drops to sustaining the passages and repassage of troops and vehicles (both tracked and untracked).

Recent advances in military tactics and technological development require updating the different army corps in all areas of military operations; ranging from combat, weaponry, movement of troops, to reception of parachute e.t.c. the choice of an area for such field training and exercises has been and is still haphazard at least in Nigeria. Consideration has always been given to the economies of operation at the expense of professional training competence and long term benefits. The choice of the training ground, Jaji the study area needs be carefully analysed for the physical capabilities apart from the evaluation of probable risk to the environment.

1.2 AIMS AND OBJECTIVES:

1.2.1 Aim

The aim of the study is to examine the appropriateness of Jaji military grounds for multi purpose military training and exercise.

1.2.2 Objectives

i. Production of Composite Map of Jaji Military Cantonment and its environs

ii. Identify and describe specific attributes of the physical landscape such as slopes, soils, vegetation and morphology of recognizable units.

iii. Classify and map the land attributes identified in (ii) for the entire study area.

iv. Determine the capability of each land unit classified in (iii) for specific military operation training or exercise. This is useful and important to the Nigeria Army because it enables the determination of the quality of part of an area to be used for military training and operations. The significant aspect of this research is the application of the requirement of terrain in terms of digability, trafficability or cross country mobility and visibility in the Jaji area.

1.3 The study Area: (Jaji)

This project is conducted at Jaji, twenty-six kilometer (26km) from Kaduna main city along Kaduna-Zaria Road. Jaji is located north west of Kaduna town. A total of 46sq kilometers was covered during the course of the project. It comprise of the command and staff college, the Infantry Corps School (I.C.S) infantry school, and other military formations.

Kaduna consists of a peneplain developed on preconsian rocks of variable composition, predominating in the triangular area enclosed by lines joining the town at Minna, Zaria and Birni Gwari. The topography is extensive, very gentle undulating plains with numerous valley steps with steep gradients separated by stretches with low gradient along the river profile. The study area (Jaji) was chosen because of its importance as a training area for Soldiers and officers of the Nigeria army, the Nigeria air force and the Nigeria Navy, its importance lies in the fact that it is the area in which military Soldiers and officers build their training upon. Secondly, the area was chosen due to its relative nearness, considering the equipment, time and resources avail-able for the research project.

Infantry corps center and school

The infantry corps centre and school (ICCS JAJI) is Nigerian premier military institution . It is the Headquarters of the infantry corps, combined with the infantry school designed to meet the training needs of the Nigerian Army (NA), consistent with the training requirements of officers and Non commissioned officers (NCOs) with emphasis on the infantry. Students are drawn from all arms and services of the Nigeria Army and sometimes from sister African countries.

The evolution of ICCS, is a product of British colonial rule. During and immediately after the second world war, the Royal West African frontier Force (RWAFF) was training all its Anglophone West African officers at Beshie, Ghana. When the British West African command was disbanded in 1956, the colonialist established Military training Institution in each of the Major Anglophone countries which Nigeria benefited. Consequently, in 1960 the Royal Nigerian Military Force training College (RNMFFC) was established at Kawo at the outskirt of Kaduna. The school however was renamed Nigerian force training college (NMFFC) in 1963 when Nigeria attained Republic status. In 1964 it was again renamed Nigerian Military Training College (NMTC). The school retained this name until 1973 when it was redesigned Nigerian Army School of infantry (NASI). In 1990, a general re- organization of the Nigerian Army necessitated the Charge of name from NASI to infantry centre and school (ICS). This re organization merged the directorate of infantry with the school. Consequently, the commandant not only heads the school, but also commands the infantry corps. The Nigerian Army (NA) infantry was however formally granted the corps status which she had advocated for a very long time, thereby reaffirming the position of the commandant of the corps commander infantry. ICCS, as it is now called, was relocated to its present location at *Jaji* in 1968. Jaji is a sub-urban town located midway between Kaduna and Zaria. The town has assumed great significance with ICCS in Jaji co – located with the armed Forces command and Staff college and a Mechanized infantry demonstration Battalion. The motto of the school is "YIELD TO NOTHING". Yield to nothing means ensuring the set objectives are achieved regardless of obstacles. There are seven (7) Training wings in the school and a training support wing. Each wing is headed by a chief instructor with a senior instructor and other instructors under him. The wings are as follows

1. Tactics wing
2. Special warfare wing
3. Platoon weapons wing
4. Support weapon wing
5. Airborne wing
6. Armored personal carrier wing
7. Peace keeping wing

8. Army Training Support centre

1.4 Focus, Scope and limitations of the study

The main aim is to assess an approach of obtaining information about the enemy /battle territory, which can be proved to be faster, reliable and more accurate than what is presently used. In other words, the usefulness of remote sensing data for military terrain modeling against the use of ordinary topographic maps (hard copy map in paper form) and sand models created from it.

The specific objectives of this project include the following:-

(i) To educate the Nigeria Army on satellite remote sensing and the roles it can play in military terrain modeling

(ii) To outline the benefits of satellite remote sensing to Nigeria Army operations

(iii) To propose steps to be taken to adopt remote sensing techniques.

(iv) To apply Remote Sensing on Military Terrain analysis.

The concept of this project is based on the fact that a war can be lost or won on the basis of the available information before and during the war. Topographic information has played very crucial roles in planning and execution of wars. These information are better understood when presented in 3-Dimensional perspective called terrain models. A very good example can be draw from the 2003 military offensive between the American led allied forces and the Iraqi military. Similar techniques were employed during the Serbian war between the American led North Atlantic Treaty organisation (NATO) forces and Yugoslavia in 1999.

Terrain models as earlier on defined, present a replica form of an area for the purpose of applying it to solve some problems. In creating a model, a digital terrain profile is generated from photographs or satellite imagery in an of – line process forming a database. The digital data are then computer processed to derive a 3 – dimensional perspective view of the terrain. One of the most extensive uses of digital profile data is the generation of digital elevation models (DEM or DTM) for use in a geographic information system and various image processing operations (Lillesand and Kiefer, 1987). It is common sense therefore that in a situation of war and with all other attendant requirements for a successful war campain, any techniques that will help to place on Army in a vantage position should be strongly encouraged using army mobility as a case study, Larkin's (1987) classified mobility in three (3) categories.

Strategy mobility: the capacity of a force to deploy into a theatre of operation from an outside base. A recent example is on the invasion of Iraq by American and British forces.

Operation mobility: the capacity to be re-deployed within a theatre of operation. Tactical mobility: the capacity of a force to maneuver to win encounters. From this classification of military mobility, it is apparent that the commander of the military must understand the environment (that is the totality of the war theatre to which he is deploying his forces for operation be it peace keeping, peace enforcing or full scale war. The precision and accuracy needed call for an approach for collecting all required terrain information that will match the 21st century weapon ammunition, professionalism and computer base planning.

1.5 Justification

This research thus attempts to solve this problem by analysing the terrain of a given area and intend to further promote the acquisition of a thorough knowledge of the terrain both for military and civil uses elsewhere. As officers will make use of this knowledge of the terrain to assess other terrains they may find themselves operating on the analysis and evaluation which is useful and important to the Nigeria Army because it enables the determination of the quality of part of an area to be used for military training and operations. The significant aspect of this research is the application of the requirement if terrain in terms of diggability, trafficability or cross country mobility and visibility in the Jaji military cantonment of Kaduna State.

CHAPTER TWO

2.0 THEORETICAL FRAMEWORK AND LITERATURE REVIEW

This chapter presents a review of previous works and literature on the subject. Section 2.1 explains the theoretical framework while the relevant literature is reviewed in Section 2.3.

2.1 Theoretical framework

The word terrain refers to the nature and configuration of the features of the earth's surface. Christian and Steward (1968) defined terrain as being the same with land. But food and agricultural organization F.A.O (1980) define terrain as "an area of the earth surface, the characteristic of which embraces all reasonable stable or predictable cyclic attributes of biosphere, the soil and underlying geology, ecology, hydrology, the plants and animal production and the result of past, present and future uses of land by man". Terrain vary in quality and are often evaluated according to specialist interests.

In this study, the terrain of past Jaji district is assessed for military use. The origin for terrain evaluation is the need for military units to move or carry out their activities effectively and rapidly (Beckett and Webster, 1969). This explains why the definition of terrain evaluation has a military connotation; that, it is an area of ground considered for its use as a battlefield or for fortification. Hence in this study military terrain evaluation is defined as the process by which the terrain of an area is analysed and classified into units with distinctive attributes and which differ from one another with respect to some selected criteria appraised for military purpose (Ologe, 1990).

Katsina (1986) has however, asserted that the general knowledge of terrain with its potential and limitations is indispensable especially when conducting any tactical military operation. Fagge (1990) explained the concept of tactical military operation as it relates to the geography of battlefield.

Military operation, relates to the general conduct of combat operation such as air surveillance, Aerobatic maneuvers, pitching of camp site and selection of best ground which can afford greater advantage to troops. Thus, military operation covers defense and withdrawal, patrol, ambush, advance and quick attack, tactical movement, deployment of troops and vehicles and the use of deception to confuse enemy's plan of action. Also, tactical operation is concerned with correct utilization, particularly of the special distribution of obstacles, visibility, the use of artillery field of fire, aerial bombardment and target accusation, which point to specific considerations of combat and non-combat situations of military tactical movements.

However, terrain, in accordance with its diversity and nature, has the property that favours one kind of military operation over another. Land, for instance influence movement, observation and efficient use of equipment. Climate and weather also affect the general operational capability of personnel especially when it is severe. Besides, flying and landing conditions are hazardous under severe climate, thus, causing difficulty in picking and destroying target.

Assessment of terrain in the military is meant for two purposes, the strategic and tactical operations. At the strategic level of operation the concern is with the distribution of important landforms that enhance their movement and / or concealment. At the tactical level of operation attributes of terrain are used. For instanc, in cross country mobility, it relate to the reaction of terrain to deformation, or bagging or cover / concealment, food storage and resources like water / fuel wood.

Plains generally favour movement or trafficability except in areas of poor soil consolidation e.g. wet clay and / or sandy environment, dense vegetation or hydrographic features such as lake, marshes, rivers or estuaries. Cross movement on hills and mountain is always a difficult experience for both troops and vehicle movement. Whereas plain areas provide suitable observations especially in area where vegetation and building do not exist.

In hilly or mountainous regions, cover and concealment from surface observation depend directly upon the amount of irregularities of the landscape. Mountains also place limitations on observation and inhibit the adjustment of artillery field, of fire. It is therefore clear that different types of terrains provide different opportunities and problems to successful tactical military operations. It is for this important law of variable nature of terrain analysis that Military interest can be appreciated.

Such information about particular attributes of land from assemblages in specific environment becomes useful planning tools for effective land evaluation and land use schemes. This supposedly, is the goal of land form studies, and this is the thrust of the present study (Hannan et. al, 1986; Hannan and Hicks, 1980; and Douglas, 1978 and 1988). Specifically, this study focuses on how best to utilize the Jaji district as a military training ground base on it geomorphological characteristics.

2.2 Review of Previous Literature

Land classification is a major subject matter in landform studies. Initially, scholars preoccupation was to categorizes areas on the basis of relief nature, geomorphic processes and the prevailing climate conditions under which they have been fashioned. Such studies gave rise to the concept of erosional (planation) and stable surfaces (Clayton, 1958; Budel, 1968; Harpum, 1963 Mabbutt, 1962). Also, scholars like Ruxton and Berry (1961) and Frylses (1969 and 1971) combined relief altitudes with several land attributes such as drainage density, valley forms and slope characteristics to classify some tropical terrain. The attempt to create ordered land from assemblages resulted in contradicting reports and conclusions about origin and processes involved in the formation of certain landforms, especially in the tropical environment. Such early studies of vast area at a G-scale between 0 and 5 covering tens of thousand of square kilometers did little more than grouping similar forms together. Doornkamp's land classification of Uganda created the need for good working knowledge for land use stability / suitability (Doornkamp, 1962). Thus, an approach which recognizes particular facets or units repeatedly occurring to form land patterns was developed (Masbutt, 1962; Backett and Webster 1985, Christian 1957; Ologe, 1985).

The land pattern that the nested units and facets make is termed "Land system". The approach make an attempt to systematically analyse relief forms, through "ad-hoc" practice. Later, land classification was approached from a multi-disciplinary point. The Australian Commonwealth Scientific and Industrial Research Organisation (CSIRO, 1949) for example employed this approach to provide blue print for development of large areas of the marginal lands in Queensland, Northern Territory, Western Australia and her neighbouring territory, Pupua New Guinea. Land classification, as approached by CSIRO requires teamwork of selected environmental scientists including soil scientists, geomorphologists /geologists and botanists / biogeography. This is not the approach used for the present work.

Properties of each land system in terms of slopes, soils, vegetation, agricultural (i.e. range land cultivation, orchard, market gardening etc.) are measured quantitatively in relation to certain land use qualities. The classification delimits homogeneous parcels of land areas with descriptions of what each is suitable given their limitations. Such land system represents the result of interaction of many factors in the ecosystems. The approach also has the advantage of integrating the complex inter-relationship of many attributes into coherent whole. Hence, where proper management is employed it reduces the risk of environmental hazards or land degradation. Beside, this land classification can be done using less expensive and readily available basic equipment such as air photos, land or morro laborious field check; provided small land area is used as basis for demarcating the land system (at G-scale of between 10 and 12). Detailed analysis and description of the different land facet terrain, soil, vegetation and hydrographical characteristics become less tedious (Ollier, 1969; CSIRO, 19750).

Another major approach to land classification is the parametric. This approach demarcates a country / region into recognizable homogeneous classes based on selected measurable land attributes. The selected attribute are precisely defined, for example values assigned to vegetation cover Characteristics may vary from 5 for total tree forest cover with thick short grass under growth, to 0 (Zero) for either sparse grass cover, (in area with short seasonal rainy months) or bare marginal land (i.e. bad lateric surface).

The procedure involves direct field observations and measurements with predetermined framework using topographic maps and air photos.

Data so collected in the field through direct measurements are analysed and synthesized for land classification mapping. Indeed, the last two decades show the urgent need for such studies of terrain evaluation for military purposes (as demonstrated in the Vietnamese war 1960s and Gulf war 1991).

Recalling the major advocates of the parametric approach, mention has to be made of the United State of American's (U.S.A) and the Canadian armies. The USA, for instance, through the Quartermaster research and Engineering Centred (QRBC) located at Natick, Massachusset, was the major founder of this approach (Mitchel, 1973). The approach was initiated by Dr. Paul Simple in 1953 in a project called Military Evaluation of Geographic Area (MEGA) which was later sponsored by the U.S. army Engineering Waters Experimental Station (USAEWES) at Vicksburg Mississippi in (1970). They evaluated the effects of terrain parameters called 'aggregate' made up of physiography; hypsometry and land form and surface conditions. 13 years during this, the basic elements in the terrain that were significant to military activities and differences of areas discovered which together gave a complete picture of the terrain. A review of the approach used in this work as reported by Mitchel (1973) has provided the background information on the techniques used in assessing the basic elements that are necessary for military activities in the study.

The Canadian army also used the method for military and agricultural land evaluation in Canada and Britain (Bibby and Mackney, 1969), in USA (Ignatyer, 1968) and for urban site and recreational planning; in USA (Kiefer, 1967). The system is useful where only a few land uses are being considered and computer facilities to handle larger volumes of data are available.

Military interest in terrain evaluation dates back to 1914, when it focused, particularly, on "diggability" and "transversability" of terrain. This interest has however grown rapidly in recent years as a result of technological advance in the production of modern weaponry (Mitchel, 1973). Past and recent wars, as well as peace keeping operations, have shown that knowledge of the character of terrain is indispensable. For example, during the 1960 American Vietnamese wars, despite the jungle training in Panama, the American troops found it difficult to compete favourably with the Vietnamese's swift's attacks. The Vietnamese's "success" was attributable to the good working knowledge of the dense forested areas and the poor "manoeuvrability" in great swampy terrain for which the Americans had no experience. Apart from emphasizing the importance of the need for terrain evaluation in military operations, Katsina (1986) demonstrated its practical usefulness during the rescue operation of the American hostages in Iran. The American Military studied the morphology and collected numerous soil samples of the enemy's military bases. They were found to be suitable and were used on landing base for their air attack on the Iranian army.

Land classification for the purpose of military operations has also been undertaken in other countries. For example, the military Engineering Experimental Establishment at Christ church, Hants (MEXE) and the soil laboratory at oxford first conceived a system for predicting terrain information by storing it according to generic individual Physiographic unit in the same climatic zone as recognized on aerial photographs. Apart from this, the Canadian army also had employed the parametric approach to terrain evaluation to assess the terrain for vehicle mobility around camp petawa Ontario (Mitchel, 1973). In this approach, certain parameters were considered such as surface composition, elasticity and viscosity of the surface materials. Large scale air photos (1:50, 000) were used to determined the macro and micro morphology of the general surface performance. The result generally indicated that vehicles performance was similar for areas with similar type of terrain characteristics and on this basis, also for cross country mobility of vehicles.

In Nigeria, the parametric approach has also been employed by Katsina (1988) in studying the effects of terrain on vehicle mobility, diaggability and cover in the Katsina area. He used the scoring method to divide the study area into suitability classes for different military purposes. The terrain attributes affecting the different military uses were selected and awarded numerical scores ranging from 0 – 10. Based on the total scores, he was able to ascertain the suitability of the area for digging of trenches, trafficability and cover necessary for any military operation.

Also the parametric approach was adopted by Bala (1989) in evaluating the terrain of the Afaka area of Kaduna for military. He followed the same procedure as Katsina's method by grouping the land into three as Good, Moderate and Poor, according to how best the area could be suitable for on and off road vehicle mobility. While for cover, he was concerned with the amount of covers available for troops camouflage and concealment. With regard to diggability, he studied the area with particular reference to escalation and how best trenches could stand or resist any external force.

Despite these series of studies and analysis , military interest in terrain information, necessitated by the continued advancement in modern warfare and military technology, the need for constant surveys of the terrain using reliable and more scientific methods to generate relevant data for tactical military operation can never be over stressed.

CHAPTER THREE

METHODOLOGY

3.0 Methodology:

In the past and up till now the Nigeria army uses topographic maps and soil sample for terrain modeling. These topographic maps, according to Patrick (1994), are complied using parametric and Physiographic personnel. Many of these maps date back to the colonial period, making them in most cases too old for any meaningful, application. As a result, the maps require updating, which has not been carried out due to the enormous financial requirement.

This project calls for in-depth understanding of what terrain model means. But a terrain model cannot be understood without first understanding what a terrain is. Buchacman (1985) defines terrain as a general term referring to the extent and physical configuration of an area viewed for a particular purpose, for example, in geographic studies and in military operations. Closely connected to the word terrain is the term terrain map, also called a relief map. A terrain map is a map that shows the surface configuration by any of the following methods, single or in combination (i) Spot heights; (ii) Contour lines and form line; (iii) layer tilling; (iv) Hachure; (v) hill shading; (vi) Cliff and rock drawing and (vii) Physiographic pictorial symbols (Mock house and Wilkinson, 1974).

Essentially, a terrain is a reconstruction of the features by means of a 3 – dimensional model is made from cardboard (each contour drawn on a card, cut around, and stuck over others in the exact position), a mixture of sawdust, plaster and glue. It can also be made from a sheet pressed over a mould, or by a vacuum forming process. The model can be painted and lettered.

A terrain type map or model is normally the final product, which shows the land surface divided into a number of categories, and shaded distinctively. Sometimes quantitative methods are used, in order to attain some degree of objectivity, and terrain types such as nearly flat plain, rolling and irregular plain, partially dissected tableland, and 'hills' are numericallymeasured. The surface of the map is girded with squares, for each of which a value is obtained, using such criteria as maximum difference in elevation, slope and proportion of near level land. Boundaries are drawn to include all areas within the same quantitatively determined categories. The digital terrain model is that softcopy of the terrain model map or sand model where features are co-ordinated and stored/presented in either victor or raster format within a computer system.

The importance and uses of terrain modeling to the Nigeria Army cover virtually all the corps of the Army. This includes: infantry, Armour, artillery, signals, Supply and transport, engineers and others. To all these corps, terrain model and its analysis provide the primary information required for strategy and tactical planning and execution. This information ranges from location, distance, direction, height of objects/places, land form, land use, land cover, soil type and texture, bedrock type, site drainage pattern and conditions, susceptibility to flood and depth of un consolidated materials over bedrock e.t.c.

The next important step is data collection for military terrain modeling. The problems of accessibility, which can be as a result of difficulties in relief, economic, political or defence related issues need to be tackled. There is a need to find a means of data collection that will circumvent all these problems. This is where remote sensing comes in. Remote sensing application refers to the group of techniques for collecting information about an object and its surrounding from a distance, without physically being in contact with the object. Electromagnetic radiation is the information link between the object and the data collector (sensor). Normally, this radiation gives rise to some form of imagery which if further processed and interpreted to produce useful data for application in environmental research and monitoring, agriculture, forestry, geology, the military (Wasternson, 1996).

The role which remote sensing can play in the Nigeria Army terrain modeling includes the following: one, it can serve as a source of both primary and secondary data. These include aerial photographs, satellite imageries and digital files. This approach has the advantages of speed and synoptic coverage. Examples include spot XS and panchromatic Land sat TM and ETM and ERS – ½ SAR. TWO, it can serve as a means of monitoring territorial boundaries and areas of potential conflicts. A good example is the monitoring of traffic volume, traffic distribution and route network in the case of any invasion. Three, as a result of the timely and continuous nature of data collection, remote sensing can be used to study the evolution and trends of subsequent changes that occur in our environment and there by providing room for up-dating the terrain – relief map from time to time. Lastly, remote sensing can be used in planning and implementing strategy and tactics in the battlefield. Here, the approach can assist in furnishing the commander with information about the whole environmental variables of the region in question. The variables include landform, land use, land cover, soil type and texture, drainage pattern and condition. These variables can then be used against the enemy.

The study area was evaluated in terms of the following environmental attributes. They are:- Visibility, Trafficability, diggability and microclimatic effects on personnel performance. The parametric approach to land evaluation was used based on the selection and measurement of certain terrain attributes. These attributes are necessary for military training / exercises. They include those of slope, soil, vegetation and major morphological features within the study area.

The approach gives detailed information about the terrain necessary for military uses. Apart from its flexibility and adaptability to technology advancements in data handling, it is analytical and therefore quantitative measure of many terrain attributes is made possible. The land system, however involves the division of the whole landscape into homogenous units which may turn out to be of less significance for immediate military operation. Also, the problem of determining the boundary on which the land classification mapping was based and field observation of soil properties. It has been shown that both the Physiographic and free survey methods are subjective, unbearably cumbersome and time consuming. At such, they were considered unsuitable for the study.

Thus, in classifying the Jaji district landscape, the field work to discuss on selection of major terrain attributes that are:

i. Manageable in number

ii. Easily recognizable in the field

iii. Simple to map

iv. Repeatedly found (or having similar characteristics e.g. form and slope angle); and

v. Have certain relationship with others

3.1 **Visibility:** Visibility is a measure of how far an object can easily be seen. This is concerned specially with cover which can be defined as that position which provides the best protection against enemy's observation while allowing the maximum observation of the enemy. It could also include provision of protection against enemy flat trajectory weapons (Bala, 1989). In evaluating the area for cover, vegetation and hill occurrences are the parameters considered in the study are. For vegetation, attention was focused on the type, density, tree spacing and tree girth of every occurring tree. In evaluating this effect of hill's presence, consideration was on the location and height of every occurring hill.

3.2 **Trafficability:** Trafficability refers to the ability of the terrain to allow vehicles and troops to move with relative ease. Terrain elements considered and measured in field include soil, slope, vegetation and surface form. Soil was considered in terms of moisture content, texture, liquid and plastic limit, plasticity index and nature of pit profiles. Slope profiles were equally measured.

3.3 Materials and data collection

However, since all military activities and training are concentrated on the North West quadrant, the choice of the method of data collection in the field presented some problems. For example, there are about three methods of soil survey sampling; Physiographic, free survey and the grid or baseline (Becket, 1968 and steward, 1961). The main differences are the determinations of the boundaries on which the land classification mapping will be based and field observations of soil properties.

Moreover there three basic of data adopted in this research work which implies three method of data collection applied.

The first one is the adoption of satellite image for proper visualisaton of the geographic features of the Study Area and the arrangement of artificial features. With this, the density of vegetation cover is given, the location of war practice zone, the reflection of hilly and flat surface, road and drainage network and or obstacle / barrier identification. All the above fact will be shown below.

The second data collection is Field Survey. The need for surface analysis in term of height specification of the study area calls for elevation data. This was collected through the use of Global Positioning System (GPS). The data was collected in XYZ format using global datum (Mina Dtum Nigeria) as reference, the unit measurement was set to metric Universal Traverse Macator (UTM).

The last method is the direct information from the user. An Army officer who is one of the current user of the Range Area and Aerodom was assigned to sully the vital information about fact encountered in the Bush Exercise area.

3.4 Data Presentation and Data Analysis

The dynamism and versatile quality of Geographic Information System operation is based on the ***Database*** creation, the comprehensive data supplied and data quality. As earlier shown, this project employed combination of different data type from different source e.g. satellite image (SPOT), soil type, type of tree and sizes and the spot height (from field survey) of the range area.

3.4.1 Satellite Image (SPOT XS 1994)

The Image adopted was collected from (NARSDA) Nigeria Remote Sensing located in Jos Plateau Nigeria. The Image was downloaded with a GIS software called "Ilwis" and it was recorded in 3 bands. The Image was captured in 4 scene, scene 1 covers North-West, scene 2 covers South-West, scene 3 covers South-East while scene 4 covers North-East of Kaduna State. Jaji town and its environs falls in scene 4 which starts form some kilometers away from Maraban-Jos a village along Kaduna-Zaria Express way and covers up to Zaria Town northward. Out of this fast land coverage, Jaji environs was identified and cut out for the purpose of this work.

The appearance of the Image is dull and difficult to analyse at inception stage. The entire surface feature appears virtually the same with little variation of gray colour see Fig. 3.1

Fig. 3.1 SPOT Image of Jaji Military Cantonment and Environs Before Processing. (Band 2)

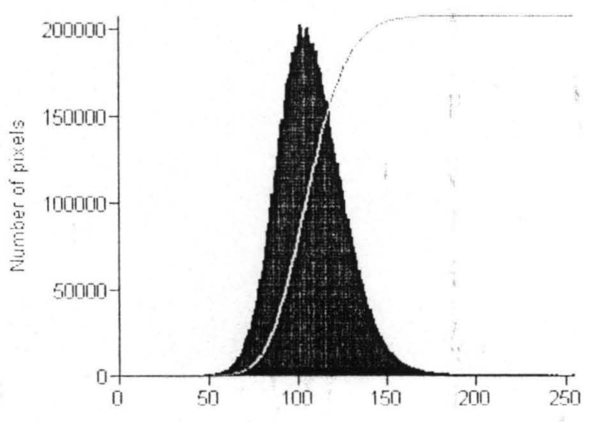
The above result of image appearance calls for image processing and manipulation. Moreover, the composite map of Jaji Military Cantonment and environs needs to be produced to give the nature, structure and ideal development of the study area. The above process supports the description of the study area and information about the accessibility of the Military Cantonment and Range.

3.4.2 Image Processing

The Composite Map was intended to be produced form satellite image (SPOT Multi-Spectral Image XS' recorded in three bands) scene 4 of Kaduna state which was taken in 1992. The satellite image was down-loaded into Ilwis Academic 3.1 (GIS software), as earlier mentioned and various processes was undergone in order to get clear information about spatial data and map spatial referencing. The major image processing carried out on this image before interpretation is based on PC workstation (single use) and is as follows.

Local Contrast Enhancement: - This was used to modify the value of each pixel in relation to or with reference to its neighbouring pixels. Through this, the relationship was established between the reflection value of spatial feature (water, rock, vegetation road, built-up area etc) in a pixel area with its value in neighbouring pixels.

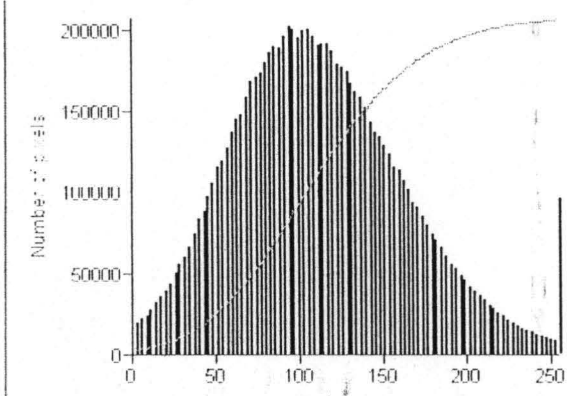
Stretching: - linear stretching was carried on the image histogram; fifty percent (50%) stretching was specified. The plot of radiometric value on the abscissa against their frequencies is expand. This was introduced to allow clarity of spatial feature, during stretching, the emitted *Spectral Value* during the Satellite capturing will be analyse and the separation of hue and colour tone is given distinctively. The presentation of result after the stretching is carried out on an image is in histogram format and can be seen in fig.3.2 and fig. 3.3 below. The effect of this operation is evident on the image appearance, see fig 3.1and 3.4 for comparism.



	npix	npixpct	pctnotzero	npixcum
0	0	0.00	0.00	
1	0	0.00	0.00	
2	0	0.00	0.00	
3	0	0.00	0.00	
4	0	0.00	0.00	
5	0	0.00	0.00	
6	0	0.00	0.00	
7	0	0.00	0.00	
8	0	0.00	0.00	
9	0	0.00	0.00	
10	0	0.00	0.00	
Min	0	0.00	0.00	
Max	202383	2.25	2.25	90000
Avg	35156	0.39	0.39	52295
StD	60491	0.67	0.67	40560
Sum	9000000	100.04	100.04	13387537

```
Mean=107.25              Std.Dev=18.87
Median=105               Pred=101 (202383)
0.0% int=  48:254    0.5% int=  65:166
1.0% int=  68:158    2.0% int=  72:150
5.0% int=  78:139   10.0% int=  84:131
```

Fig. 3.2 Image Histogram before Stretching



	npix	npixpct	pctnotzero	npixcum	npc
0	88844	0.99	0.00	88844	
1	0	0.00	0.00	88844	
2	0	0.00	0.00	88844	
3	18942	0.21	0.21	107786	
4	0	0.00	0.00	107786	
5	0	0.00	0.00	107786	
6	21832	0.24	0.24	129618	
7	0	0.00	0.00	129618	
8	0	0.00	0.00	129618	
9	23552	0.26	0.26	153170	
10	0	0.00	0.00	153170	
Min	0	0.00	0.00	88844	
Max	202383	2.25	2.27	9000000	
Avg	35156	0.39	0.39	5094750	
StD	61006	0.68	0.68	3261265	
Sum	9000000	100.08	100.01	1304255898	14

Mean=108.35 Std.Dev=49.98
Median=108 Pred=94 (202383)
0.0% int= 0:255 0.5% int= 8:255
1.0% int= 11:254 2.0% int= 19:232
5.0% int= 34:204 10.0% int= 48:180

Open Column Management dialog box

Fig. 3.3.Image Histogram after Stretching

The above figure is the numeric representation of the image processing operation (stretching). The importance of this is to analyse the spatial feature for proper clarity. During Image capturing, there many factors that constitutes dull appearance of Satellite Image e.g. weather condition, Satellite Sensor orientation, Environmental refraction, etc. Stretching Operation allows Computer Software to adjust the

Colour Composite: - Image recorded in bands have the unique application of their wavelength. Since the acquired image was Spot-Multispectral of 3 bands (Band1, Band 2 and Band 3), the three bands were combined to give the ideal cartographic colour interpretation. The general function of electromagnetic spectrum in each band (1-3) can be stated thus: **Band 1**; This is blue wavelength (λ) or blue band of visible light, water body penetration ability and is hereby applicable to coastal area.

It is also use for soil and vegetation discrimination, forest type mapping and cultural feature identification. **Band 2**; This is green wavelength (λ) for measurement of green reflectant peak of vegetation. **Band 3**; This is Red wavelength (λ) that senses chlorophyll absorption to differentiate species of vegetative component, it can be used in forest management where monitoring of hazards is necessary. There are some other LANSAT TM (LANSAT Thematic Mapper) Image which are captured in seven Band i.e. Band one to seven (1to 7).

Band 1 (TM1):- This is blue wavelength (λ) or blue band of visible light. The band width value ranges between $0.45\mu m - 0.52\mu m$, it is useful in Water-body penetration, Vegetation discrimination and Forest type Mapping.

Band 2 *(TM2)*:- This is the green wavelength (λ) or green band of visible light with its band width value ranges from $0.52\mu m - 0.60\mu m$. It is use to measure the green reflectance of peak vegetation.

Band 2 (TM3):- This is also a green wavelength (λ) that sense the Chlorophyll's absorption, it has its band width ranges from $0.63\mu m - 0.69\mu m$ it is use for vegetation species differentiation.

Band 4 (TM4):- This is wavelength (λ) of NIR (Near Infrared), it has the band width ranges from $0.76\mu m - 0.90\mu m$. At this band the vegetation reflects in high proportion than visible light. It is also useful in water body delineation and soil moisture discrimination. It facilitates BIOMASS i.e. it tells about the living and death vegetation.

Band 5 (TM5):- This is the first of the two (2) of MIR (Middle Infrared). The band wavelength (λ) ranges between $1.55\mu m - 1.75\mu m$ It is useful in the temperate region for differentiation between snow and cloud cover on atmosphere.

Band 6 (TM6):- This is the band of FIR (Fear Infrared) also known as Thermal Infrared; It senses direct contact of object. It has its wavelength (λ) ranges from $10.40\mu m - 12.00\mu m$ It is useful in thermal mapping application, streets analysis and soil moisture discrimination.

Band 7 (TM7):- This band is the second band of MIR (Middle Infrared) wavelength (λ) and it is the last band of LANSAT TM. The band width ranges between $2.08\mu m - 2.35\mu m$ and it is use in the discrimination of minerals and rock types mapping.

Colour composite is created and displayed on the screen, by combining the spectral values of three individual bands. Each band is displayed using one of the primary colours but the output in Ilwis 3.2 Academic will be somehow equal until the Analyst gives the specify colour in the Opening dialogue box, if not, the only difference that exists is based on the sharpness of the image. These entire bands were combined to show the natural features of the study area. The arrangement of the band during composition is directly related to the interest of the analyst; the possible combination is in six major form {(123),(132),(213),(231),(312),(321)} though there is possibility of combination of two band only in the colour composition with repetition of one of the band, but this have the defect of neglecting the record reflection of one band and so incomplete. For the final image, the combination used is (213) and the out-put of the processed satellite image is described in Fig 3.4.

Jaji town and its environment is a typical example of good terrestrial surface which contain geographic features. There is an existence of all important features both natural and artificial. The interpretation of the final result is as follows. The black reflection is the rock outbreak; the magenta reflection is the developed area; the dark-gray is the tarred road; the blue reflection is the water body while the gray-white is the open space/bare land.

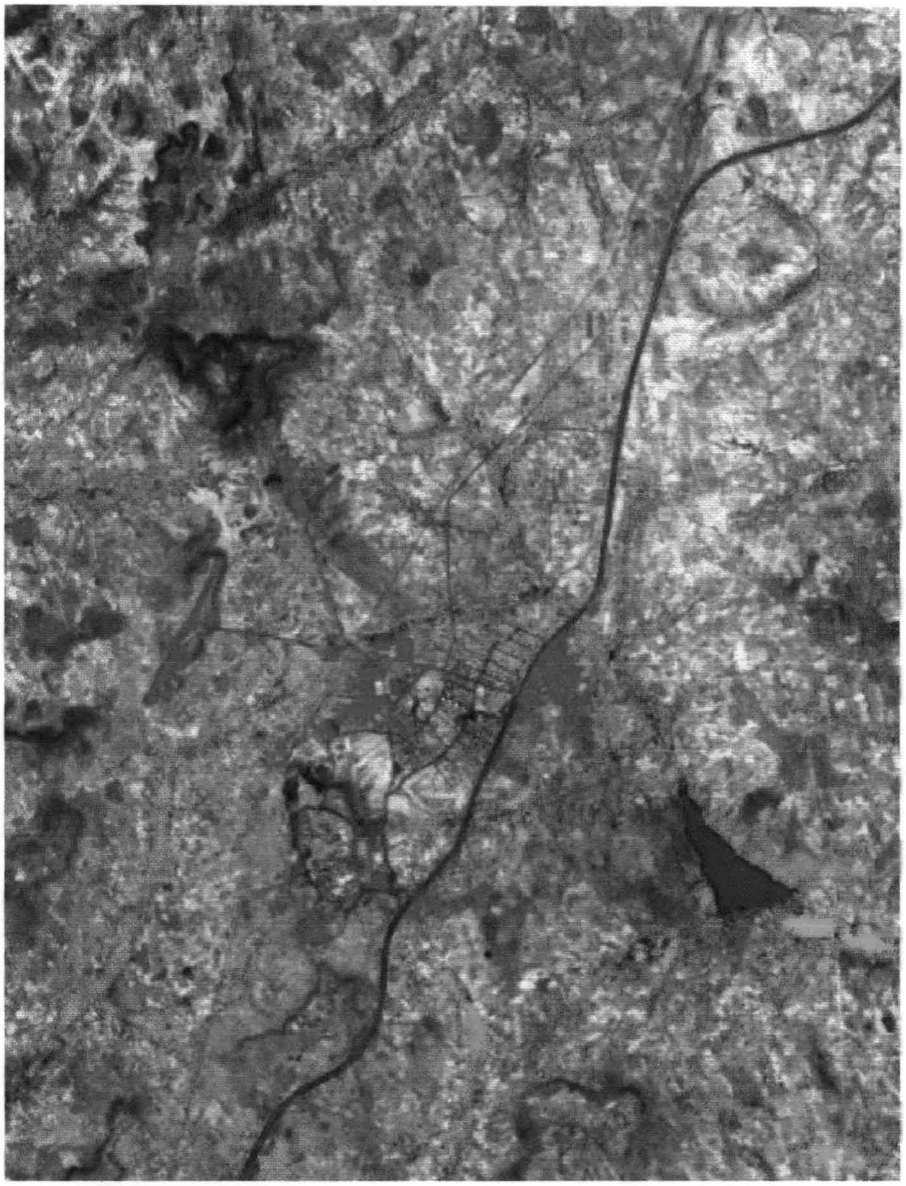


Fig. 3.4 SPOT *Image of Jaji Military Cantonment and Environs after Processing.*

The Satellite Image covers wide area from some distance after Maraba Jos and some distance after Zaria town. The total coverage of the above image was carved out of the entire image after processing by using image editing software called Photo Plus4.

Moreover, during the band combination, all the seudo-colour were ignored and the true reflectance colour was adopted.

Image Interpretation

The general interpretation of the above image (fig 3.4) is as follows.

Natural features:

Vegetation; the reflection of green appearance is signifying vegetation cover grasses, shrubs, and trees. This feature is sparsely distributed i.e. the area is moderately having plant coverage except the town central. There are high concentrations of green colour reflection either as linear or polygon form within the image. The linear form gives the fresh bush concentration along the streams while the others are the bush area scattered around the Study Area

Hydrographic Features; these are water bodies e.g. Steam, Dam etc. A well pronounce feature of this type is a dam towards the south-east of the fig 3.4 above. The streams were obscured because of the coverage of tick vegetation cover at their banks.

Soil Type; there are two colour representations for soil type, the open spaces of hard clay soil is reflecting in whitish wile the hard laterite is reflecting in dark brownish and both can be seeing scattered all over the area.

Artificial features:

Road; there are four (4) major road type, (1) Dual Carriage Way (2) Tarred Road (3) Untarred Road and (4) Rail Line.

The Dual Carriage way runs from south-west to north-east of the coverage area and it reflected in dark brown. The thickness represents the width of the road. The layout tarred road and Untarred road reflected also in dark brown the only difference is the prominence of the reflection. On the other hand the Rail Line is shown in black faint colour reflection, it can be seeing at back of Military Cantonment.

Building; Building is a feature that occupies the developed area, the roofing materials shows magenta colour in the image. The concentration of building is at the central region of the coverage area showing both the village houses and the entire Military Cantonment houses.

Map Reference: - *Remotely sensed images in raw format contain no reference to the location of the data. In order to integrate these data in a GIS, it is necessary to correct and adapt them geometrically, so that they* *have comparable resolution and projections as the data sets* (ITC Ilwis User's Guide). After the proper image processing, there is clarity of spatial features and the out put map is appropriate for direct interpretation by any map analyst, Each spatial feature is seen clearly, based on conventional cartographic colour but there is need for *georeferencing* which will give the possibility of location representation (the co-ordinate on PC copy will give the exact co-ordinate on ground of a particular location). To do this, data export was carried out from Ilwis to ArcView using Raster Image format (Bmp). Six conspicuous points were identified on the image and Global Positioning System (GPS) was used to take the X/Y co-ordinate of these geographic locations on the field using UTM projection. The X / Y coordinate points are shown in the table below.

X Coord.	Y Coord.	Description
342137	1194951	First Gate form Kaduna to Zaria
341046	1195408	Rail Line and the link from Weapon Junction
341988	1197519	Rail Crossing along Range Area Road
341780	1198780	Shooting Range Junction
343168	1196899	Stream and Tarred Road Towards North
344212	1197374	Kaduna Zaria Express way and the Stream

Table 3.1 X and Y Spatial Coordinates

The referencing was carried out in ArcView GIS software after which the vectorization was carried out.

CHAPTER FOUR

4.0 VECTOR DATA CREATION, DATA ANALYSIS AND PRESENTATION

4.1 COMPOSITE MAP

After the image processing, the final result gives a satisfactory result (fig. 3.4) upon which vector data can be produced. The application of Remote Sensing facilitates easy and quick way of analyzing the input data for further research work. It is through this method that the production of composite map of Jaji town and its environs was made since there is no existing Base Map for the study area.

Vector Data:-The adopted method is *on-screen digitizing* system since the conversion is from soft copy raster data, form (satellite image) not hard copy map which may employ tablet digitizing. In ArcView, each map feature needs to be represented as a theme with proper declaration of the type of spatial feature to be created (Point, Line and Polygon). The Composite map of Jaji Military Cantonment and environs was produced in form of vector data to which further manipulation and analysis have to be carried out.

The Composite Map shows shape of Study Area and possible existing development with natural features available, the location of area of interest in this research work is also indicated on the composite map as Aerodom and Range Area (fig.4.1)

Moreover, the representation of the Spatial Features on the Composite Map shown in fig. 4.1 can be analysed thus:

Linear Features: - The group of Spatial Features that fall in this group stem from Roads of different kinds, Streams and Contour line. The mode of differentiating these features is of two different categories

(1) Natural characteristics of each feature: This is the direct behaviour of some features under normal circumstances; Streams for example have the characteristic of joining another in angle less than 90^0 against the direction of flow. Other thing is meandering nature of stream base on the relief of earth surface. Roads on the other hand normally have a fairly straight line formation with little and smooth curve, also the Rail Line. But Contour line is a different feature because is a professional sign to give the height value of surface elevation. The formation of Contour Line may not be specifically defined since it can be straight, arc form and or circular in nature.

(2) Cartographic Colour Representation: This follows the globally accepted colour representation, there are specific colour assign to some features for example, water bodies are known with blue, vegetation with green, road

with black etc. This was adopted also for description between the feature in the Composite Map production. The streams are coloured in blue, roads are coloured in Black, and rail line also is in black with a checked line feature. Contours are coloured in brown see fig 4.1 below.

Polygon Features:- Under these category, we have both natural and artificial features. The example of artificial feature are mountains, open spaces, dams, areas of vegetation cover etc. while the artificial features are built-up areas or any other feature design for a specific use(s). In this study area, the polygon features identified are: Built-up areas, Mountains and Bush Exercise Areas (Shooting Range and Aerodom). The description of each feature are shown in the map legend fig. 4.1

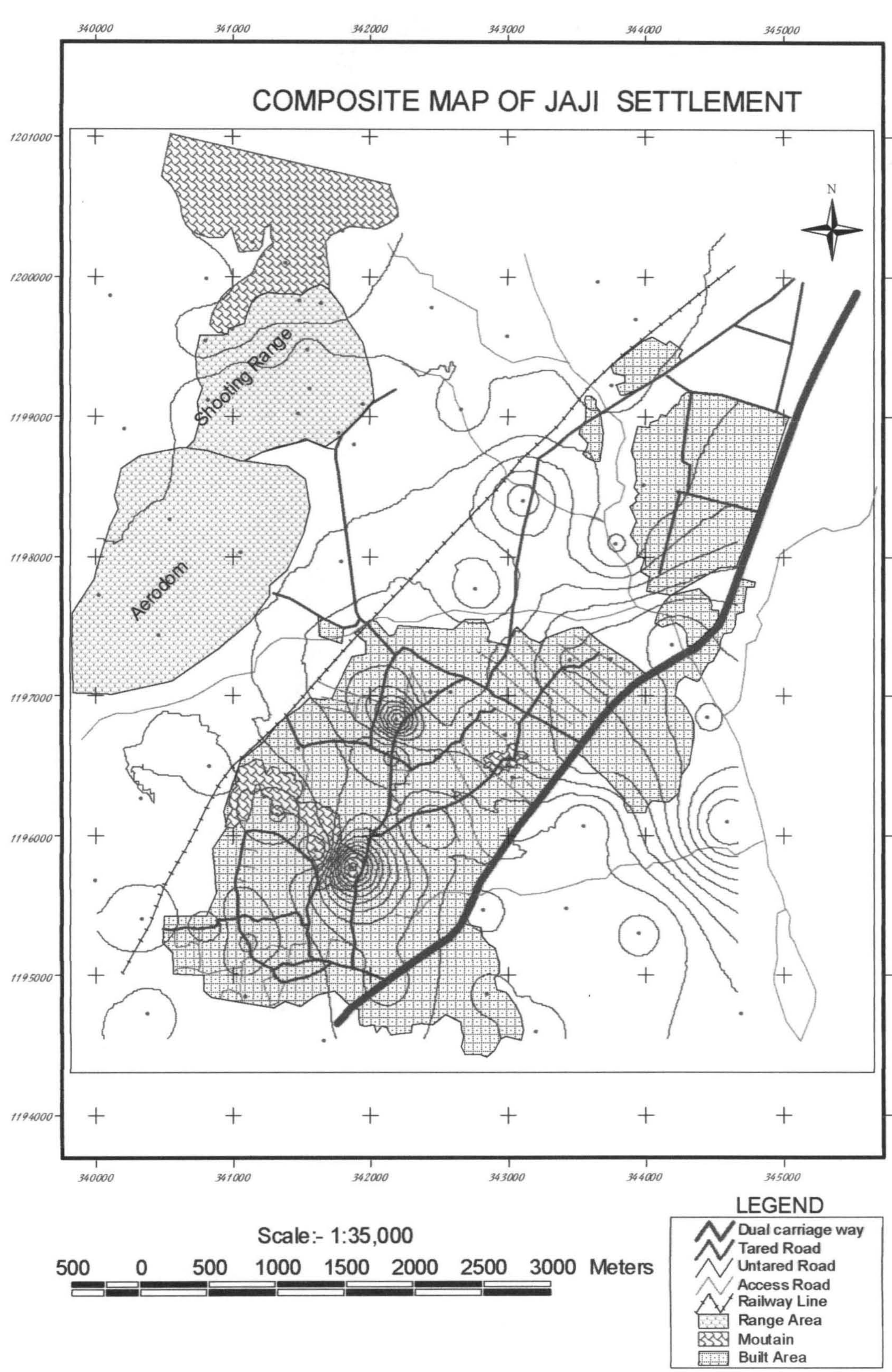


Fig 4.1 *Composite Map of Jaji Township*

4.2 CARTOGRAPHIC MODEL

The Cartographic Model presents the logical stage of the project framework wherewith the channel of work must show. The military terrain analysis is supported by some spatial data through which the data integration was based.

Cartographic Model is a graphical representation of data and the analytical procedure use in the study i. e. (data + analysis = information). It gives the process of linking or organizing operation in a logical sequence such that the output from one is the input to the next. It gives a tailor made map processing capabilities that can be use to tackle many analytical problems in GIS data processing. The logical and sequential involvement in GIS manipulation and analytical way of solving complex problem(s) is conceived in Cartographic Modeling.

The basic model for vector geographic information systems breaks down our perceptual and physical reality into three basic data types (points, line, and polygons). These three gives the cartographic location of phenomena expressed typically in x, y coordinates associated with a geodetic grid or measurement system. In addition to these is the attribute information describing the characteristics of these primitive locations. All the data type applicable to a project must be structured, linked and integrated in a logical way to create a comprehensive database that will support the target analysis.

The data and metadata component of this work comprise raster image (SPOT XS 1994), the coordinate geometry (COGO), field record for soil sample, field record for vegetation type and information from the user of the study area (range land).

The logical model which is the insight of the researcher on how the GIS operation will be carried out is formed out of the data and metadata listed in the previous paragraph; the result shows is used as a new data for further operation until the final result is generated. The data input or generated is put in the box, metadata is put in oval shape and the operation is given in a kite shape. The logical model also serves as the technical way of creation of comprehensive database which is the central focus of GIS design and implementation.

The database design includes two types of data, spatial data and non-spatial data. Spatial data are the information that have geographical references or location while non spatial data are those with descriptive status (no geographical references). In line with this work, spatial data are satellite image; cartographic map, spot heights and non-spatial data are information from the officer in charge of range ground, e.g. type of gun, bullet, and facilities for shooting velocity distance which was used in security measure.

The spatial and non-spatial data can be stored separately or stored together. When stored separately, it means that spatial data is stored in a GIS and non-spatial data will be stored in an external database. In this case there will be a need for link creation so that the data stored in the external database will be recognized by the GIS data for integration and analysis. In this work, the data, both spatial and non-spatial data were stored together in ArcView GIS, the spatial data layer as input theme and non-spatial data as attribute tables.

Cartographic Model is represented by the flow chart fig 4.2 to indicate sequence of operation, explicit assumption, and relations between variables. The diagram shown in fig.4.2 is the logical model design of how the framework of the analysis was carried out. It guides the analyst on the interrelationship of the data, identification of data needed, the structure of the procedure and their systematic integration in Remote Sensing and GIS software environment.

Logical Model ER Diagram of Military Terrain Analysis

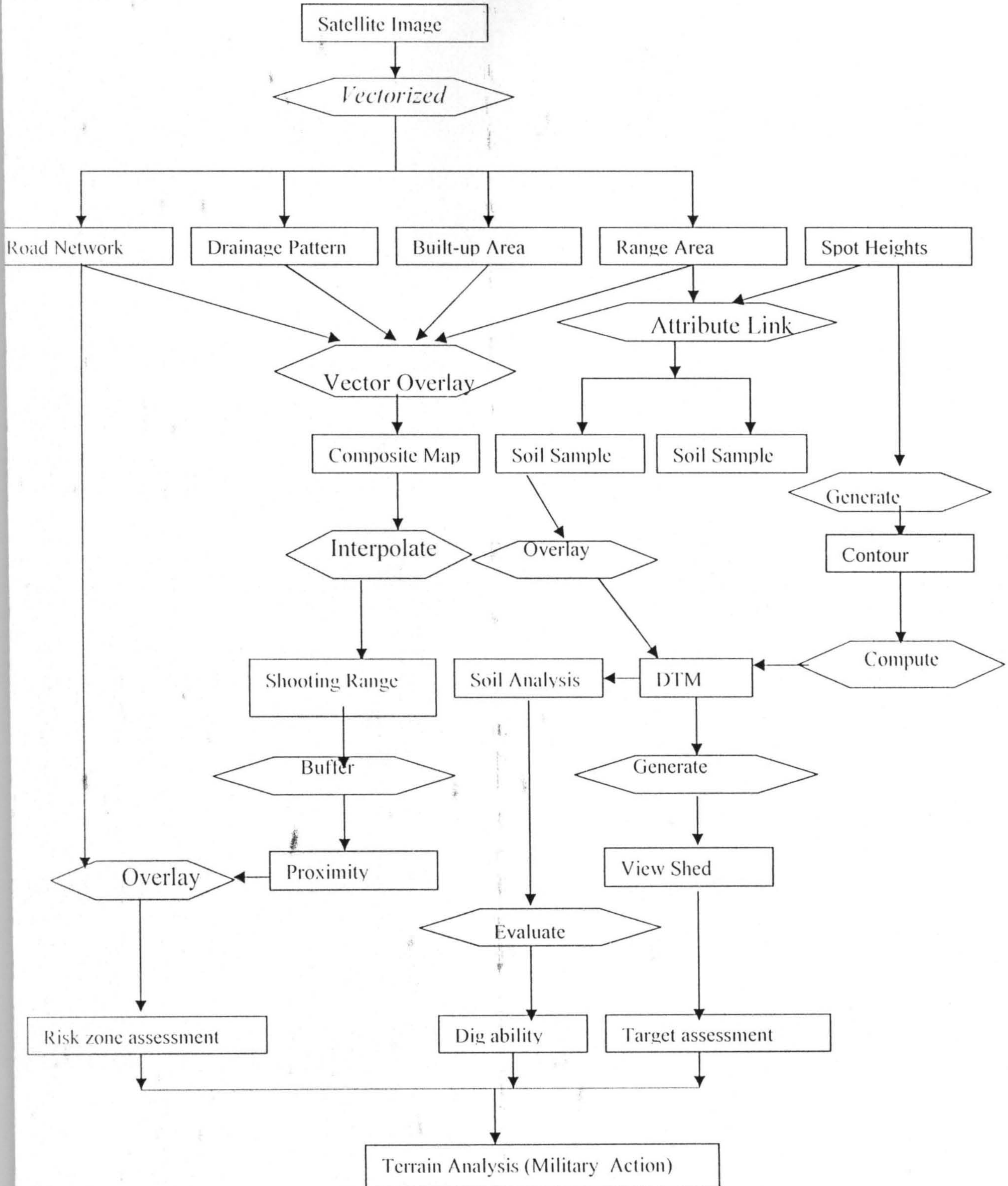


Fig.4.2 Cartographic Model(ER Diagram)

4.3 ROAD NETWORK

The road network of Jaji Township and its environment can be viewed from the vector map generated from the satellite image. After the image referencing, the road was digitized as line feature with classification based on the size and finishing materials. There are four (4) classes of road, (i) Dual carriage way (ii) tarred road (iii) access road and (iv) untarred road. In the cartographic presentation used in this work, all road colour is black. The dual carriage road is thick due to the width, tarred road is diced double line, access road in double line, untarred road is in single line and railway line is in track format. The road network of civilian part of the settlement is not identified because that side was not laid out; the building is just distributed irregularly, this is the reason why the road on civilian part of the settlement is ignored. The un-tarred road and open space is reflecting equally. On the other hand the road network within the Military Cantonment is good and the accessibility can be said to be convenient, the reason is that the Military Cantonment was built on a well laid out plan. Another transportation medium recognized in this area is the railway line at the rear end of the Military Cantonment. The vector map of road network within the Military Cantonment Area with the various types of road was shown in fig 4.3

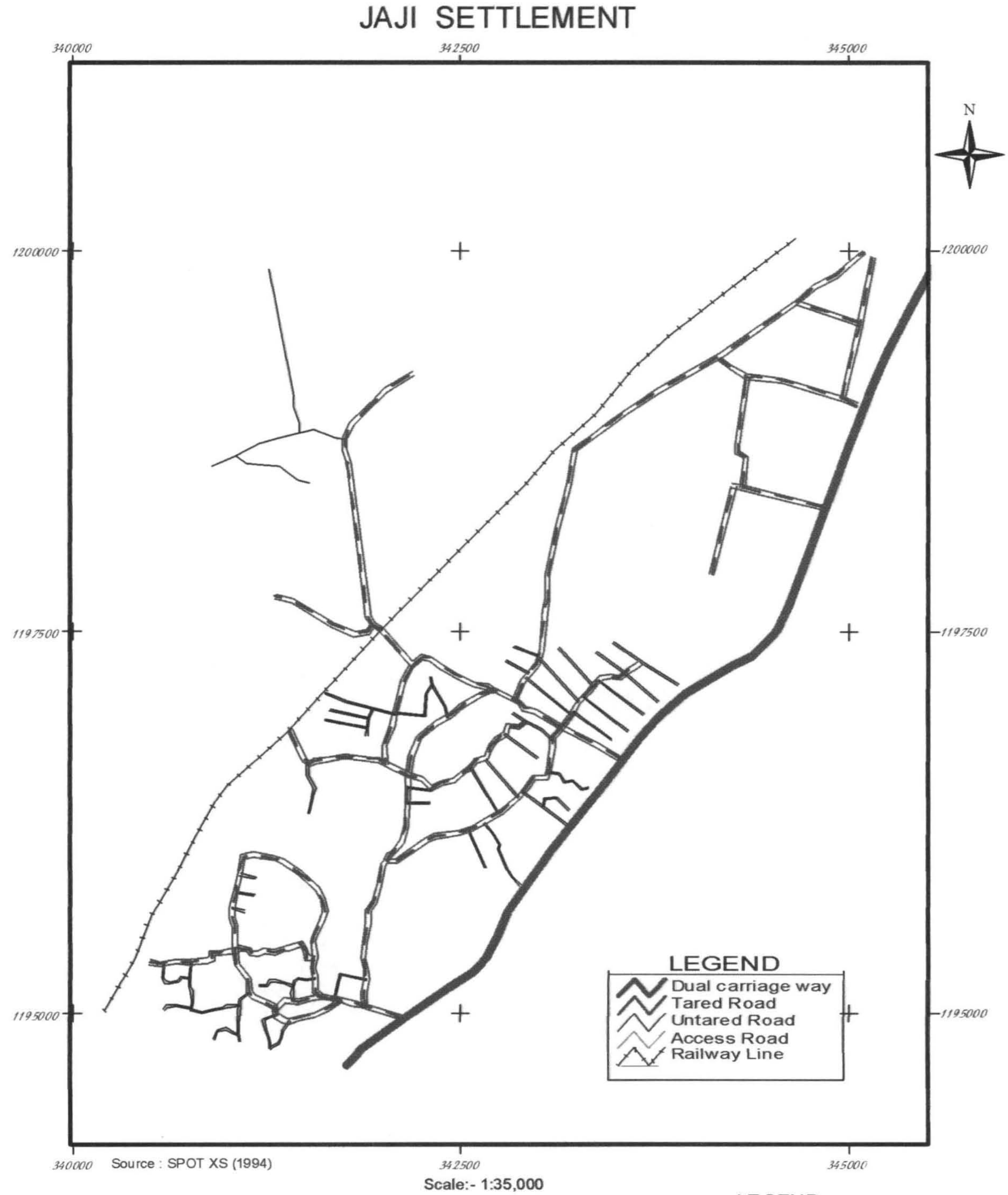


Fig. 4.3 Road Network

4.4 CONTOUR CREATION

Contour map is a vector map that gives the height information about the surface of the earth. The contour interpolation using ArcView GIS was based on the field survey; the spot height of range area was taken by Global Positioning System (GPS). A table was created where there are provisions for XYZ Coordinates with minor description of the soil sample and or the location of the place in which the point is taken table 4.1. The X-coordinate stands for the Easting, Y-coordinate is the Northing and Z-coordinate is the Elevation above the sea level.

Table 4.1 GPS Data (XYZ) and Description

X Coordinate	Y Coordinate	Z Coordinate	Description
344212	1197374	656	Express & Stream
342137	1194951	684	First Gate
340352	1195407	687	
343120	1198405	671	
344469	1196853	655	Stream Link
344608	1196098	661	Stream Curve
342455	1197032	686	
342509	1197029	685	
342606	1197029	685	

342523	1197197	684	
341988	1197519	685	Rail Crossing
341810	1197962	691	laterite soil
342168	1196563	695	cross junction
342017	1196635	689	T junction
341493	1196633	692	
341334	1196156	705	
341617	1195897	703	lateritic
341046	1195408	704	weapon junction
340847	1195347	688	soft soil
341117	1195226	706	laterite
341301	1195031	697	soft soil
341106	1194851	697	hard clay
341882	1195776	692	soft gravel
342209	1196834	690	
342744	1196869	677	
342989	1196721	680	
343463	1197258	667	
343765	1197267	663	
343168	1196899	674	Stream & Road
343546	1196662	668	Second gate
341574	1199199	695	
341662	1199817	708	Mountain Side

341499	1199832	708	Mountain Side
341011	1199623	708	Mountain Side
340812	1199547	708	Mountain Side
341560	1199476	696	Sand
340833	1199120	694	Sand
341056	1199267	694	Sand
341489	1199023	693	Sand
341967	1199089	693	Sand
341784	1198886	694	Hard Laterite
341896	1198805	694	Hard Laterite
340474	1197442	697	Sand
340223	1198914	700	Sand
343016	1199583	672	Sand
343953	1199700	680	Sand
344003	1198512	667	Sand
343970	1195301	700	Sand
342832	1195468	700	Sand
343568	1196070	698	Sand
342448	1196070	698	Sand
340340	1196271	698	Sand
341076	1198027	698	Sand
340390	1194732	700	Sand
343217	1194599	700	Sand

344706	1194732	679	Sand
342464	1199783	671	Sand
340123	1199867	700	Sand
340558	1198261	698	Sand
342682	1199047	685	Sand
342782	1197776	698	Sand
343802	1198094	669	Sand
343434	1195485	678	Sand
340842	1196505	700	Sand
341678	1194532	700	Sand
342866	1194866	679	Sand
343769	1199231	673	Sand
343669	1199967	682	Sand
340825	1199984	700	Sand
340039	1197726	698	Sand
340006	1195686	700	Sand
341394	1200101	709	Laterite
341645	1200135	709	Laterite
341160	1200252	709	Laterite
341812	1200335	709	Laterite
344826	1195417	675	Alluvia
345016	1196075	677	Alluvia
344912	1196854	680	Alluvia

344895	1197529	682	Alluvia
345224	1198083	684	Sand
345605	1198308	692	Sand
344601	1199398	689	Sand
344549	1197996	682	Sand
345033	1198775	686	Sand
343943	1200385	692	Sand
344704	1200385	695	Sand
345501	1200195	690	Sand

The interval (1 metre for contour of Jaji and its environs and 0.5 metre for Shooting Range) for the contours was limited to the range limit of the spot height. The system for interpolation is Nearest Neighbour and IDW system of line type. The topographic shape is reflected by the contour height. In this research work, the contour line shows the areas of equal height in form of line feature.

There are two types of contour presentation in this work, firstly, the Contour map of the whole Jaji settlement and its environment, and the contour of the Range area where the *Bush Exercise* operation is being carried out.

4.4.1 Contour Map of Jaji Town

Based on the height source generated from field survey, using GPS (Gamin IV) the contour interpolation was carried out subject to the above specification (*Nearest Neighbour and IDW line format*). The difference in surface height is shown in numeric value. Also, the overlay operation was carried out by combining the spatial feature both man-made and natural to form the "Composite Map of Jaji Town" Fig 4.1 above.

The contour interval is set at one metre (1 metre) i.e. any height difference less than a metre will be generalized. With this result, the idea of how low or high a particular development in an area is given above the sea level. The understanding was clearly depicted by contour representation of the study area Aside from ordinary relief understanding, a decision can be made on which part of the town is suitable for strategic location of Relief Based Project e.g. Borehole, Communication Mast, Town Hall etc.

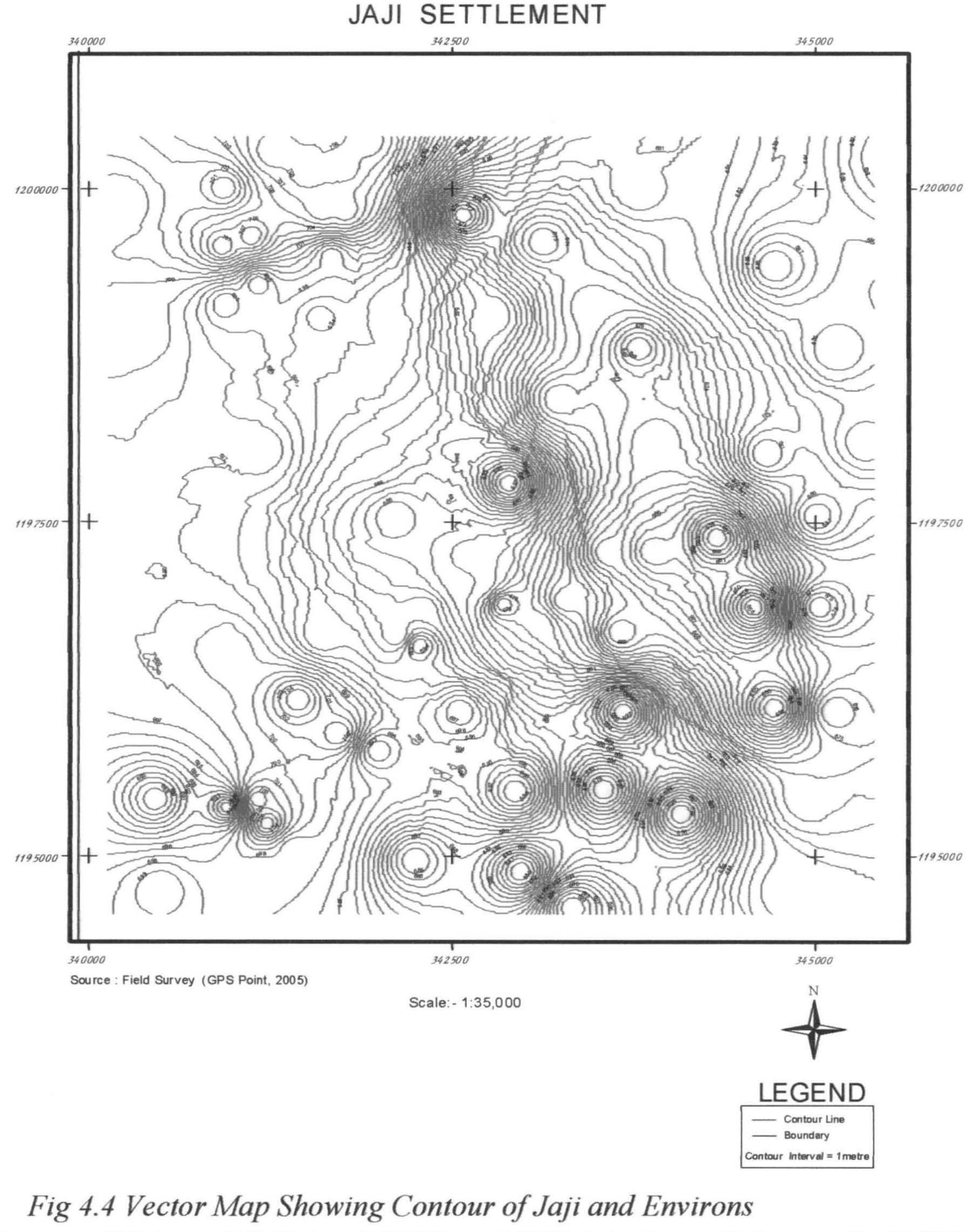


Fig 4.4 Vector Map Showing Contour of Jaji and Environs

4.4.2 Contour Map of Range Area

The need for Bush Exercise (Military war demonstration Practice) analysis calls for contour generation of Range area, the Topographical Map of the whole Jaji town cannot give the data suitable for the Range analysis because the there will be feature generalization and the necessary information will be hidden. For example, the unit of contour interval needed for the line of site in order to calculate visibility result during targeting is minimal e.g. 0.5m or 1m. The same method of interpolation was used as specified above (4.4), but the Contour interval is 0.5 metre. The representation of the relief in the Range Area is shown in fig 4.5

Moreover, the height source from this Contour Map is used for the creation of Triangulation Irregular Network (TIN). TIN is the Digital Terrain Model (DTM) representation digital format (ArcView Software Presentation).

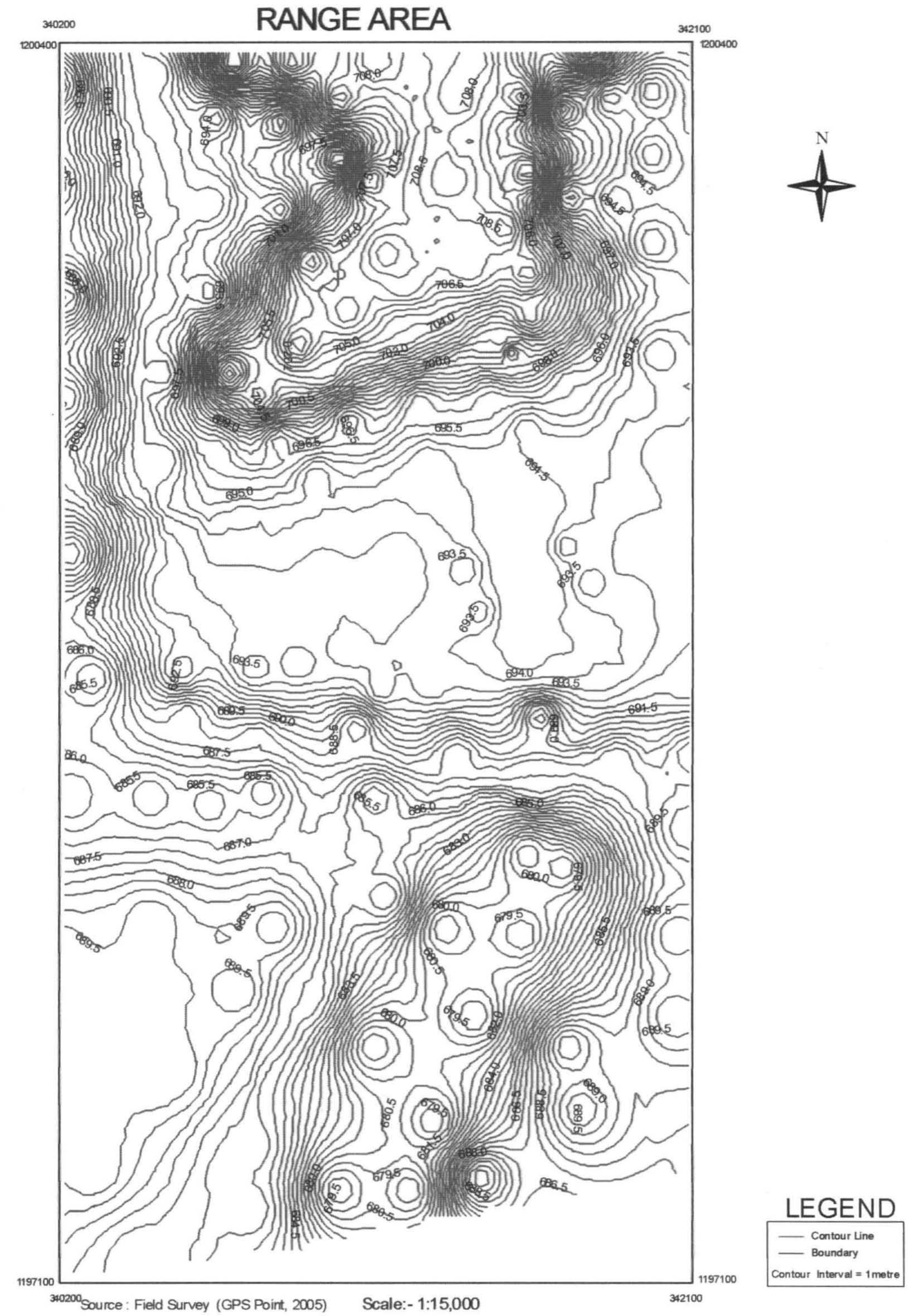


Fig 4.5 Vector Map Showing Contour of Range Area

4.5 DIGITAL TERRAIN MODEL (DTM)

GIS design involves different aspects of geographic view; there is need for terrain analysis to see the actual topographic nature of the study area. Aside from contour which is the difference in the height in line format, Digital Terrain Model is graphical representation of height difference of a particular area of the Earth's surface. The variation in height will be seen in both colour and three dimensional (3D) form. This will help the analyst to observe the digital map and decide why a particular exercise should be carried out at a given place of project area..

Moreover, the DTM computation was limited to the Jaji Township and Range area, for the use of these two coverage areas differ. The entire Jaji Township was used for the location assessment of military cantonment and important feature distribution so as to confirm the functionality of the installed utilities. This is relevant in this research work to justify the effectiveness of artificial spatial feature distribution in relation to geographic principle. On the other hand, the Range Area was analyzed to examine the risk zone, shooting and target visibility, safety security, soil digability and accessibility in case of rescue service subject to unforeseen contingencies.

Moreover, the computation of Triangulation Irregular Network (TIN) gives the height value information both in colour and terrain model representation. This operation was carried out using the height source from contour created. As stated above, the TIN model of the Range area is shown below (Fig 4.6) at the scale of 1:15,000. The colour Variation shows the difference in height from one area to another.

RANGE AREA

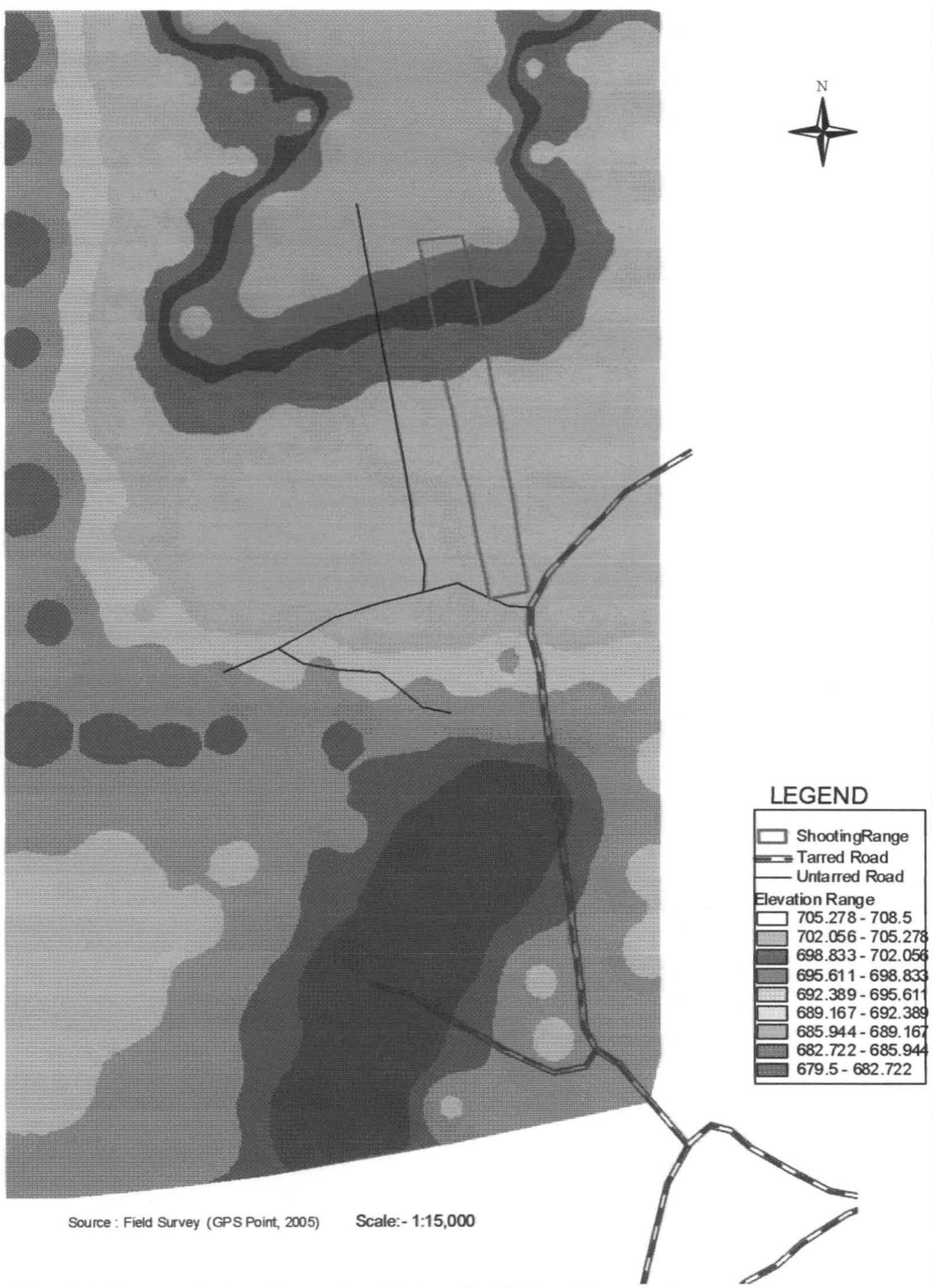


Fig 4.6 Triangulation Irregular Network (TIN) of Range Area.

From the above Digital Terrain Model (EM) there are many facts hat can be drawn. This fact is based on the interval uniqueness, although there are some little undulation which will not be shown due to generalization default of the computation method. The area of equal height is merged to have equal surface elevation view and a unique colour shade is given.

The height representation starts from the highest relief area of the earth surface. The surface of highest value of elevation is given an approximate value that falls within the range of 705metres to 708metres with representation of whitish colour. The next relief has the value representation of 702metres to 705metres with hash colour representation. Next to it is the elevation value of 698metres to 702metres with thick brown. Follow by the elevation value of 695metres to 698metres with light colour. Next to this is the elevatin value of 692metres to 695metres with orange colour. Next to it is the elevation value of 689metres to 692metres with deep orange. Next to it is the elevation of 685metres to 689metres with colour of light green. Next to it is the elevation value of682metres to 685metres with deep green colour representation. Lastly is the lowest surface area, the value starts from 679metres to 682metreswith colour representation of dark green. See figure 4.6.

Furthermore, there are different analyses to be carried out based on the above model and its features. The analysis starts from Accessibility, Security, Visibility and Operational flexibility of the place.

Moreover, there are different slope classifications in the area. It is obvious from figure 4.7 that the variation in elevation gives the sample of probable terrain that can exist elsewhere during the war combat. The southern part of the area has am gentle slope of 20 degrees and above while the northern part has a steep slope from 10 degrees to less than 5 degrees. Army Corp(s) trained and certified in this environment will survive in other difficult terrain either home or abroad.

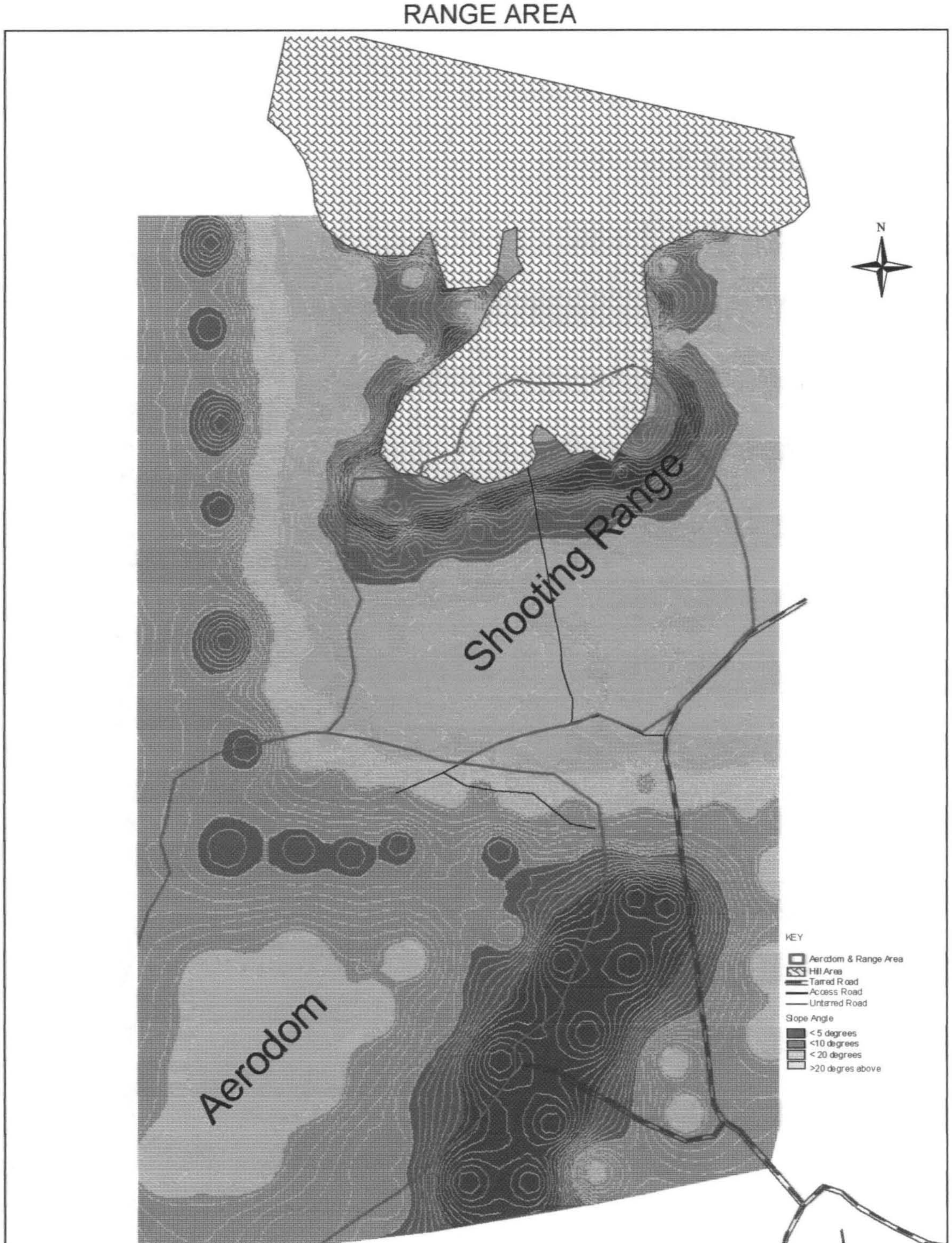
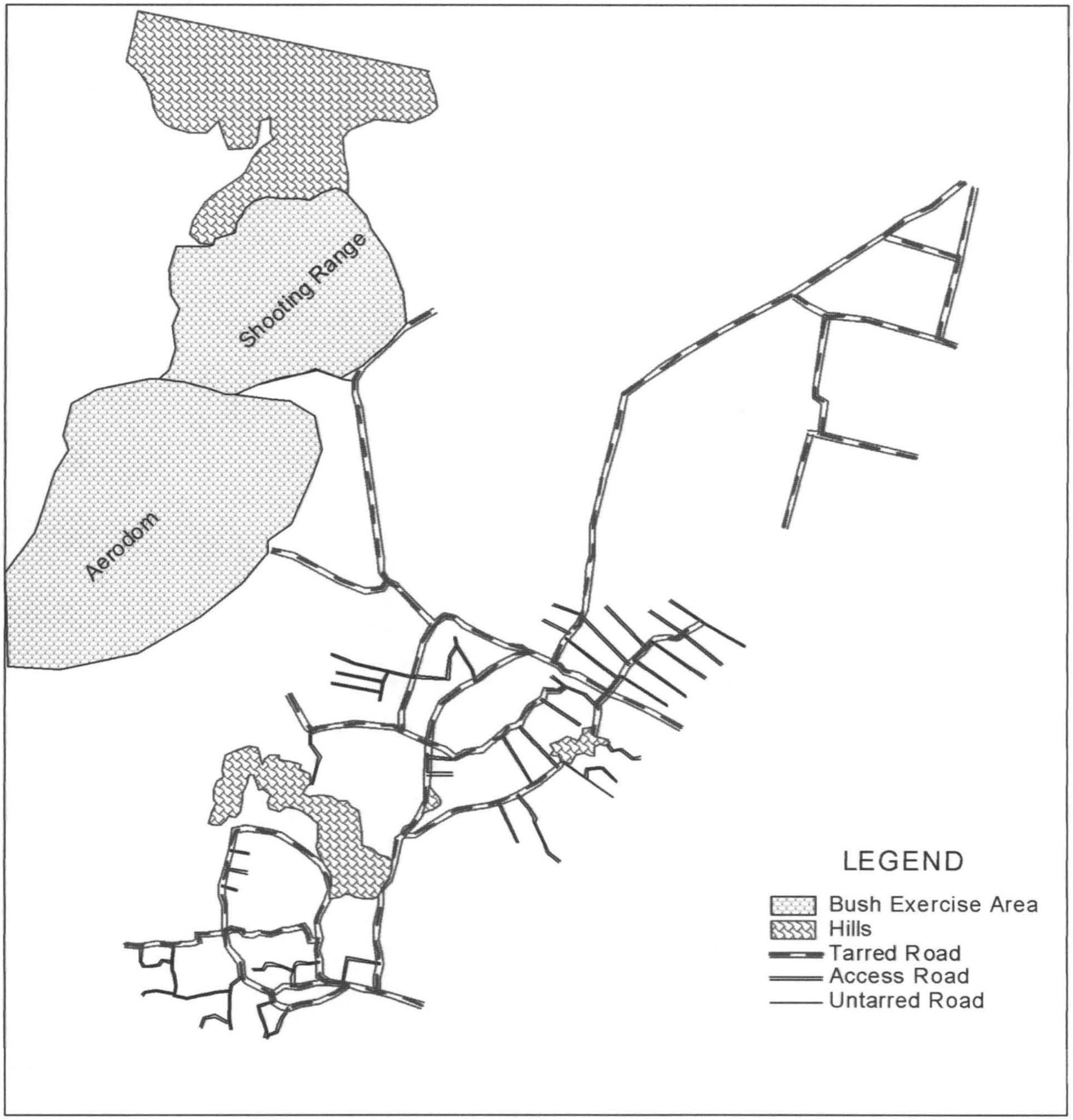


Figure 4.7 slope variation result.

4.5.1 Accessibility:

The road network of the whole Military Cantonment is adequately planned and this gives free movement within area. The access road to the Range Area passes through the Cantonment and therefore it is easy to reach by the any Military officer from their various quarters. The main road toward the Range Area was tarred and the other roads that ware not tarred within the Range Area are well maintained. On the other hand, access is denied to civilians around the Range Area for safety purpose. The civilians around are cautioned with various signs. Also, there is no road leading to outside villagers through which trespass can be committed, figure 4.8 depicted the road network and dangerous area where shooting of guns are been carried out. Then, the accessibility to the Range environment is favorable to the Military and any other legal user because it denies trespasses to avoid accident and injury.

JAJI TOWN AND ITS ENVIRONS



SCALE :- 1:35,000

Fig, 4.8 Map showing accessibility to the Bush Exercise Zone

4.5.2 Security:

From the information gathered and eye witness, during Bush Exercise, the practice of Target Shooting which is the major operation on the Soothing Range calls for a predefined rule and regulation. One, the target object must be placed in front at a measured distance towards North direction. Two, there are specified types of gun to be used for an exercise at a time depending on who are to be trained. The height of the object is usually ranged within the height of human being. Under normal circumstances, human height varies depending on the status from Dwarf to Giant people. Since there is no static height value an average of 1.6m is chosen. The Shooting Range is already marked out with a ridge at distance of 100 metres apart, the Target Object are placed at the ridge for the Observer(s) in practice.

The topographic nature of the Shooting Range is of high benefit to security during this exercise because about 1000 metres away from the first ridge is a natural hill 700 metres high. The hill is a hard laterite type of soil. Now the security of the civilian (villagers) outside the Cantonment is not at risk because the bullets that are out of target cannot escape to harm people around. Perfect study of the road network shows that the unconscious trespasses in highly denied, before a man can get to Range Area through any of the access road he/she must pass through the Military cantonment. Therefore, the trespasser will be challenged or cautioned by some of the officer in charge of security. Also, a trespasser will be visible from a far distance by the corps during the war demonstration practice. For instance, if a man is moving on the top of the hill towards the northern direction, there is possibility of seeing him right from the outskirts of the Cantonment, then from the Shooting Range and the Aerodom, the visibility is very clear to avoid gun accident. Base on the view shed generated result shown in figure 4.9. Corps can be trained on how to hide in a similar terrain of battle field. The Corps are advised to hide on those area where visibility of the enemy is obscured.

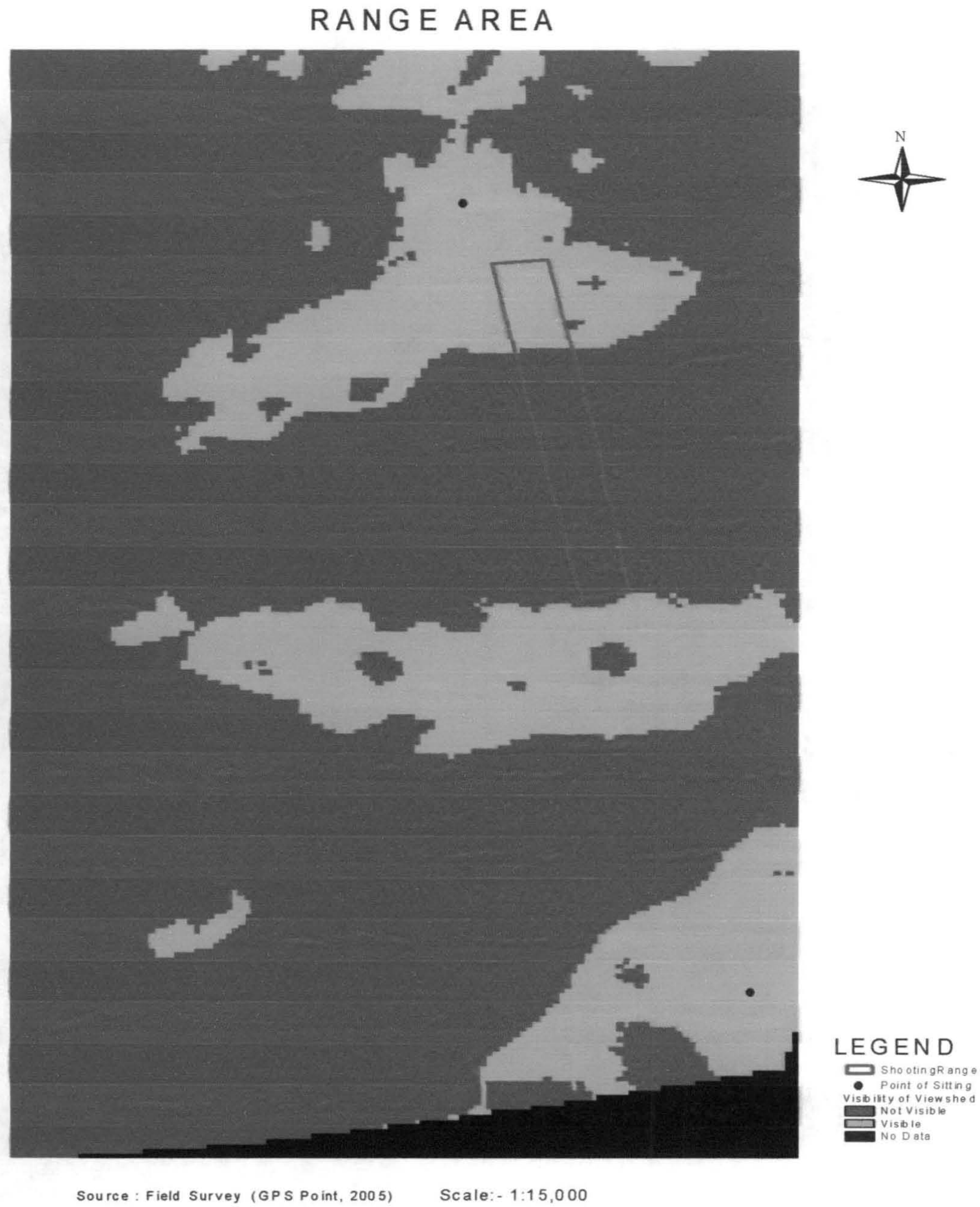


Fig. 4.9 Result of viewshed computation.

The result achieved (fig 4.9) gives the colour interpretation of the visibility result of the Range Area. The area with green colour is the visible from the two choosen stations of black dot (•), the red coloured area the invisible area from the same point whereas the thick black at the base signifies that there is no spatial data for computation.

4.5.3 Inter-visibility

The visibility operation model in this project was carried out to show the possibility of target recognition. The operation involves standing at a point and sitting object subject to direction and distance. The inter-visibility operation shows that the planning of the study area is well organized. The operation was limited to the Range Area in this work because it is the area where the gun shooting is been carried out. The exercise was generalized, that is, both the Shooting Range and Aerodome was viewed together. The figure 4.9 gives the probability of site been seen at different locations base on the terrain model or topography of the area without any target or an observer with assumption that there is no obstacle or hindrance. The obstacle can be trees, building or any artificial structure, these features may serve as hindrance even if the terrain of the earth surface is inter-visible because the height of the artificial feature will block the view of observer peradventure the observer's height in addition to the surface height is lower than that of obstacle.

The flexibility of the operation is another sensible analysis that can be carried out under this model. This operation is directly related to shooting and targeting during model war practice organized by the military in preparation for war outbreak or challenge. With this model, a Soldier will know if there is possibility of shooting and get the target at a particular place subject to direction and terrain structure where he/she is standing in proportion to location of the object of target.

With the result of inter-visibility operation in figure 4.10, Jaji Military Cantonment is a good training ground to equip army corps in all area of military operation. The area has the different types of terrain feature which can be met during combat, weaponry, reception of parachute, movement etc.

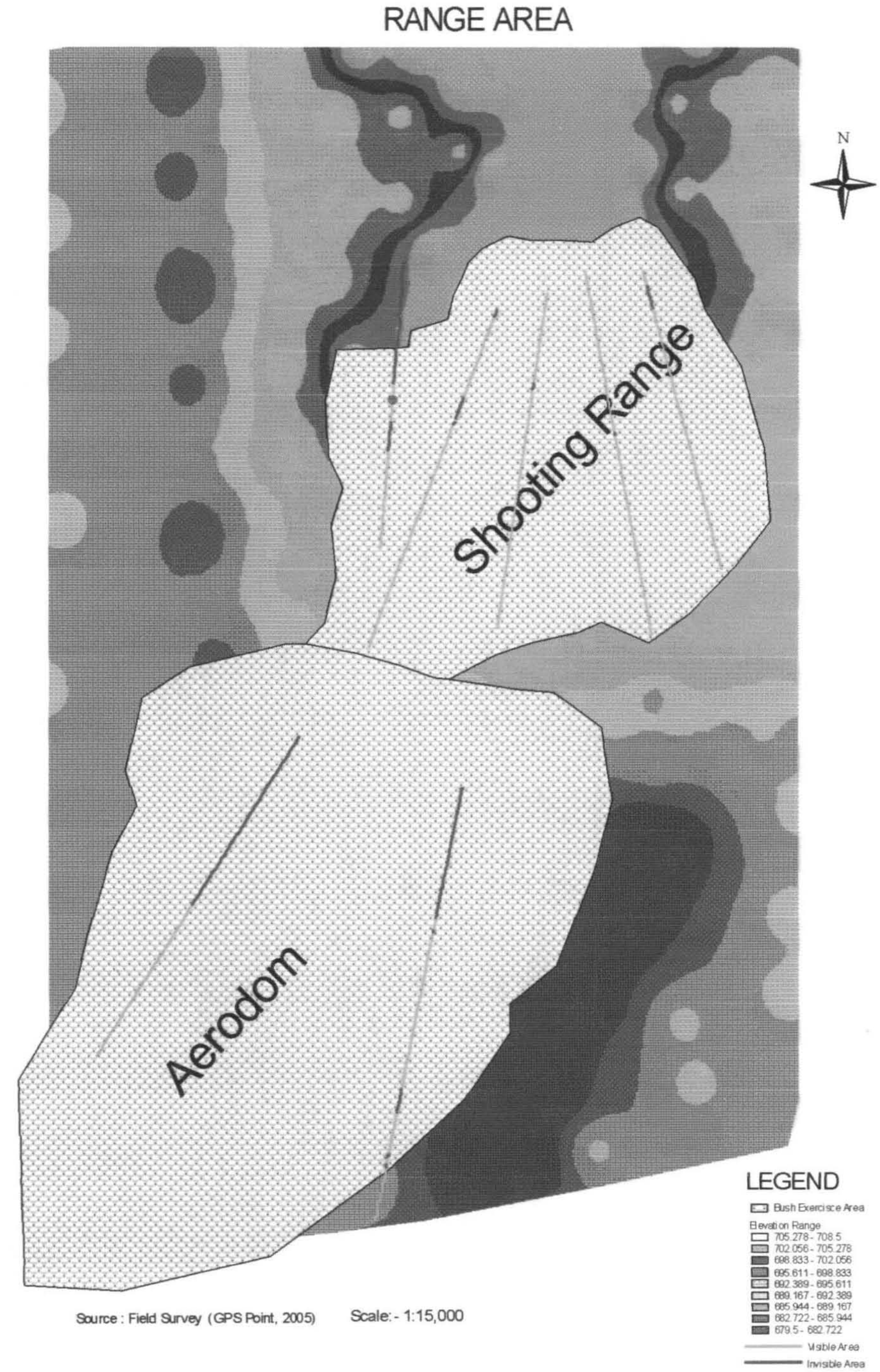


Fig 4.10 Result of Intervisibility through the line of site

4.5.4 Risk Zone

The Risk Zone assessment is calculated so as to make sure that adequate caution can be made for the nearby villagers. This is achieved through buffer operation, since there is possibility of misfiring and target missing. An assumption was adopted for average distance to which the bullet can move in respect of the types of gun that are normally used for the exercise in the range area. The only limitation to the distance calculation is the topographic nature of the area, though there are some places closer, but due to the high topography the bullet can not escape to it. For example, the northern part of Shooting Range which have up to an average height of 750m. Therefore, the buffer operation for Risk Zone assessment is limited to the west, south and eastern side of the Range Area.

To carry out this operation, an average distance of 500m (0.5Km) is adopted from the Bush Exercise Area, (Aerodom and Shooting Range inclusive). The figure 4.11 shows the result of Risk Zone assessment through which a decision can be made to warn and challenge the trespasser to avoid the risk of gun shot. In the aspect of warning, a sign can be put to indicate danger; a barrier structure like wire-fence can be put round the place to serve as a boundary of danger zone.

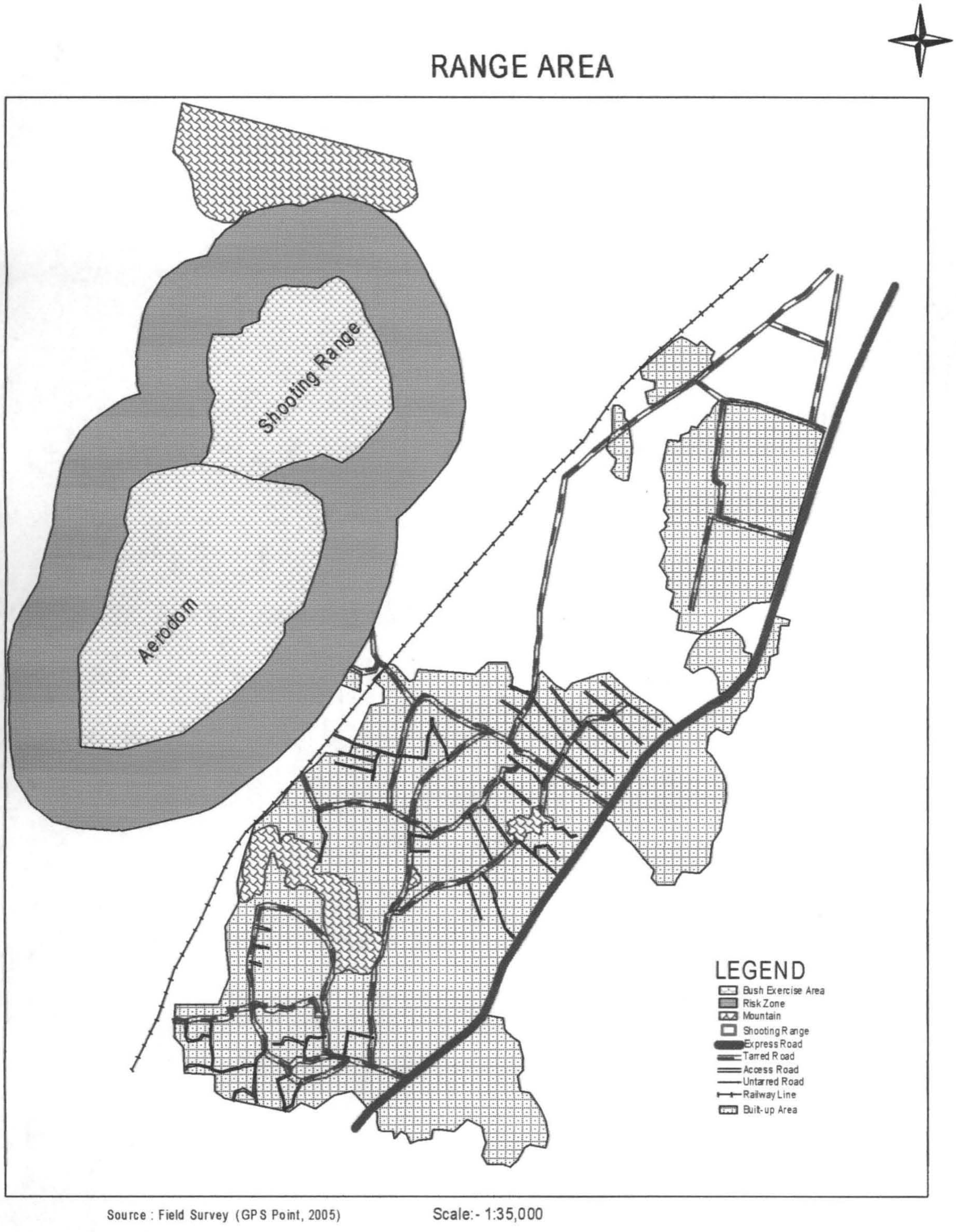


Fig 4.11Risk Zone

CHAPTER FIVE

5.0 SUMMARY AND RECOMMENDATION

5.1 SUMMARY

One of the major problems facing military operation that determines the success of a nation in war combat is the ability of the troops in question to understand how to move in the battle ground. There is the need to give an appropriate training to military force even before the challenges of war come closer. The word "Appropriate Training" must be given a kin observation because it has to do with where and how it is being given. Base on this, a training ground needs to be analyzed weather it can serve the purpose of preparing the army "appropriately" for the task ahead.

The aim of the researcher as stated in chapter one is to examine the appropriateness of Jaji military ground for multi purpose training and exercise. The aim was followed by four objectives. 1. Mapping the entire Study Area. 2. Physical Landscape identification. 3. Classification of identified Landscape attributes. 4. Determination of capability of each land unit identified for specific military operation.

Chapter two of this research work gives the review of past literatures on military terrain and Remote Sensing application to spatial problems.

To achieve the stated aim and objectives, there is need for Remote Sensing data since there is no existing base map of the Study Area. The suitable available data was Satellite Image (SPOT XS). This was collected and an appropriate processing was carried out to help in extraction of useful information. The major analyses carried out were Local Contrast Enhancement, Linear Stretching and Colour Composite for proper identification of surface feature for study area Mapping. Together with this Satellite Image, a field survey was carried out to get the spot height with Global Positioning System (GPS). The GPS data was used for two major purposes, 1. Image Referencing and Orientation. 2. Location and height value for determination of landform of the study area. The data and method of data processing adopted was discussed in chapter three.

The results of the operation carried out in chapter four shows the map of the Study Area, and how suitable is the Study area in preparation of Nigerian army for war outbreak. The spot height recorded gives the difference in height from one location to the other through which contour of topographic surface was drawn. From the Trianglelation Irregular Network (TIN) computed, the terrain model was shown with variation of elevation height and the slope angle difference. After the computation of TIN and Slope, the viewshed analysis was carried out for security measure, and strategic planning of hideout during gun shooting in the war front.

The accessibility study carried out gave a favorable support to cross country mobility and tafficability. This was established through the road network possibility within Bush Exercise Area.

The Inter-visibility operation carried out gave an encouraging result. It gives an intelligence measure toward the possibility of getting target object at a particular range distance. If this study was carried out before setting out for battle, the soldier(s) will know where to get is enemy or where he/she can not get during shooting.

The only limitation to the study is non-availability of data for measuring the digging-ability of the soil base on soil type or structure.

5.2 RECOMMENDATION

The present age discovery and the growth of science and technology bringing changes in the way and manner of service delivery in various fields. For any organization or an establishment to meet the standard of the present demand, there must be proper upgrading with digital application. The structure of military organization calls for full application of Remote Sensing and GIS so as to upgrade strategic planning and implementation.

Finally, the following recommendations will help in fulfilling the focus and aspiration of both the military organization and the nation to which their service is needed.

Preparation: - War is not an incidence to be prayed for, but it do come to establish fact(s) in life. Therefore for any battle, this research can be used as preparation measure towards achieving success. It is a form of ground work that facilitates battle strategic planning. The terrain nature of where the battle can come up can be model via this study.

Data Capturing Sensitivity: - In Remote Sensing and GIS, data is the most valuable factor that facilitates adequate study with good result. The quality of data input is capitalized on the output (information). Current data capturing is need, for example, Satellite Images, Aerial Photo, land Survey data and Cartographic data (Hard-copy Map) of high accuracy must be always available. Also, the available data needs to be kept in secured place to avoid spoilage, error introduction, lost of data etc. Since satellite images are the most effective data presently, different type of this image must be available for comparison, test of accuracy and analysis. If there are data availabilities e.g. Soil strength measure, Quick-Bird Image of high resolution (5 metres resolution) it will improve the study further.

Request for Study of Other Military Base:- Its is recommended that these study can be carried in all the military base in Nigeria to observe weather they are up to standard for training our soldiers for battle.

The above recommendation can observed through the help of the following factors.

Government Support: The first help for the solution in any national problem the governing body of the state. If our government can reinforce the adoption of the modern system of operational analysis to the Nigerian Army, the structure and planning will definitely changed. This support can come in various ways. Firstly, provision of financial support by earmark special budget for purchase and installation of digital devices of Remote Sensing and GIS. Others are facilitating local production of those digital accessories and recruitment of Remote Sensing and GIS expert to the Nigerian Army.

Corps Literacy Improvement: - there is need for good education facilities in Nigeria Army towards the usefulness and benefit of Remote Sensing and GIS application in the modern day's defense and security provision. By this those in the organization will have the understanding of what can come as a benefit for their individual life and their nation at large. The higher the assurance of proper security for army officials, the increase is the encouragement for their commitment. The public enlightens can be achieved through a provision of chance for the corps to participate in further in order to have experience in some of these educational courses. Another way is to create Remote Sensing and GIS laboratory which will have sophisticated equipment in each of the military base throughout the nation for practical education and invitation of expert to carry out some of these operation even before the need arise. The study outside the country must not be over emphasized, situation where there must be provision for study abroad to have a wide knowledge and international experience.

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