© 2010 Cenresin Publications
www.cenresin.org

USING NON-BOOLEAN STANDARDIZATION AND WEIGHTED LINEAR COMBINATION IN GEOGRAPHIC INFORMATION SYSTEM (GIS) FOR SITE SUITABILITY FOR MILITARY BARRACK IN JALINGO, TARABA STATE, NIGERIA

[1*]Ikusemoran Mayomi and [2]Joshua Jawa[2]
****Department of Geography, University Of Maiduguri, Maiduguri***
Department of Geography, Adamawa State University, Mubi, Nigeria

ABSTRACT

In this paper, Non-Boolean Standardization and Weighted Linear Combination (WLC) were applied to site suitability for military barrack in Jalingo, Taraba state, using remotely sensed data and GIS techniques. In this method, factors were not reduced to simple Boolean constraints, that is, defining a location as absolutely suitable or not suitable, but were standardized to a continuous scale of suitability from "0" (least suitable) to "255" (most suitable). The WLC allows trade off of the factors, that is, a low suitability score in one factor, can be compensated for by a high suitable score in another factor. In this paper, road network, drainage and ecology conditions, distance to already developed areas, the topography as well as suitable landuse of Jalingo metropolis were considered for modelling site suitability for military barrack. The result revealed that the suitable site for military barrack in Jalingo is located in the south-eastern part of Jalingo town around Alkali Yabba settlement. This suitable site is connected by the major road from Jalingo town. The total suitable site was calculated to be "1643.54" hectares of land with a distance of 6.5kilometers from Jalingo town. The method can easily be manipulated to derive desired results because town planners may use different factors or combination of factors to model their planning.
Keywords: Criteria Development; Fuzzy; Non Boolean Standardization; Waste Disposal, Weighted Linear Combination:

INTRODUCTION

Jalingo has been the headquarters of Jalingo Local Government Area since the defunct Gongola State that was created in 1976. When Ibrahim B. Babangida - the former Military Head of State of Nigeria, created Taraba state on the 28th of August, 1992, Jalingo became the state capital. Since its inception as the state capital, it is unfortunate that the town has not been provided with any military barrack, that is, army barrack or air force base. The need for military barracks in state capitals cannot be overemphasized; it stabilizes the security consciousness of the people in the area by protecting their lives and properties and also minimizes crime rates. Moreover, the presence of government institutions and parastatals in these cities calls for organized and competent institutions that will protect these huge investments from vandalisation, theft and from external attack. Hence, the need for military barracks in the all the state headquarters is highly desired.

Housing planning is basically resource generation, resource development and resource management exercise. The efficiency largely depend upon how well they are developed and how efficiently they are managed. The urban development planning process in the past has been unduly long and has been largely confined to the detailing of land use aspect; the plan

has paid inadequate attention to the provision of trunk infrastructure, environmental conservation and financing issues. A development plan is essentially a blue print for development along desired lines for a particular horizon. In addition to the general layout, it addresses issues related to development on virgin land, heritage conservation, environment, improvement of an old city etc. Pesaresi (2001) noted that the nature of planning addresses the nature of sites that are currently impacting, as well as those that have the potential to impact human in an area or the environment. Special rules apply when housing development is involved. In this case, the site must be decommissioned prior to using the land for a designing purpose. The aim of decommissioning is to ensure that the end product is a site that is: not risk to human health and safety, not the cause of unacceptable effects on the environment, in compliance with all applicable laws and regulations, suitable for proposed purposes, not liable to current and future owners, aesthetically acceptable for the proposed project, and not closer to mining site such that will restrict development or even relocation of the project.

Thus, land suitability analysis is the process of determining the fitness of a given tract of land for a defined use (McSherry et al 2000). In other words, it is the process of determining the suitability level. In other to determine the most desirable direction for future development, the suitability for a various land uses should be carefully studied, with the aim of directing growth of the most appropriate sites. To establish an appropriate suitability one most constructs a suitable analysis technique which three factors need to be considered: location, development activities and environmental processes. These techniques can make planners, landscape architects and local decision maker's analysis which interact in various ways.

Johnson (1992) stated that efficient town information system is a vital pre-requisite for planned development. The increase demand in town planning and management sectors call for coordinate application of Remote Sensing and Geographic Information System (GIS) for sustainable development of urban areas. According to Flora, (2004), there is an urgent need to adopt Remote Sensing and GIS approach in urban planning development and monitoring process for implementing pragmatic plan of housing development. Burrough, (1986), concluded that the plan must incorporate an integrated approach of spatial modeling using Remote Sensing data, GIS database and GPS solution. This helps in evolving efficient and economic models for development and location of service facility housing as observed by Florent (2001).

Richards (1994) observed that the reference to "acquire" land suitability refers to land which meets the operational requirement and environmental guide lines. Therefore, GIS and Remote Sensing has the capabilities to capture satellite images such that areas that are suitable in the map can be easily depicted using GIS technique. GIS can receive process, create, store, retrieve, update, manipulate and compress digital terrain data in order to provide a proper analysis of the area. This process can only be achieved through overlaying maps with point set theory of different GIS packages. Mitchell, (2005) concluded that land suitability analysis can first be carried out with physical parameters alone and next with additional environmental parameters, using GIS utilities like overlaying, buffering and

clipping, by employing network analysis facility of the GIS.

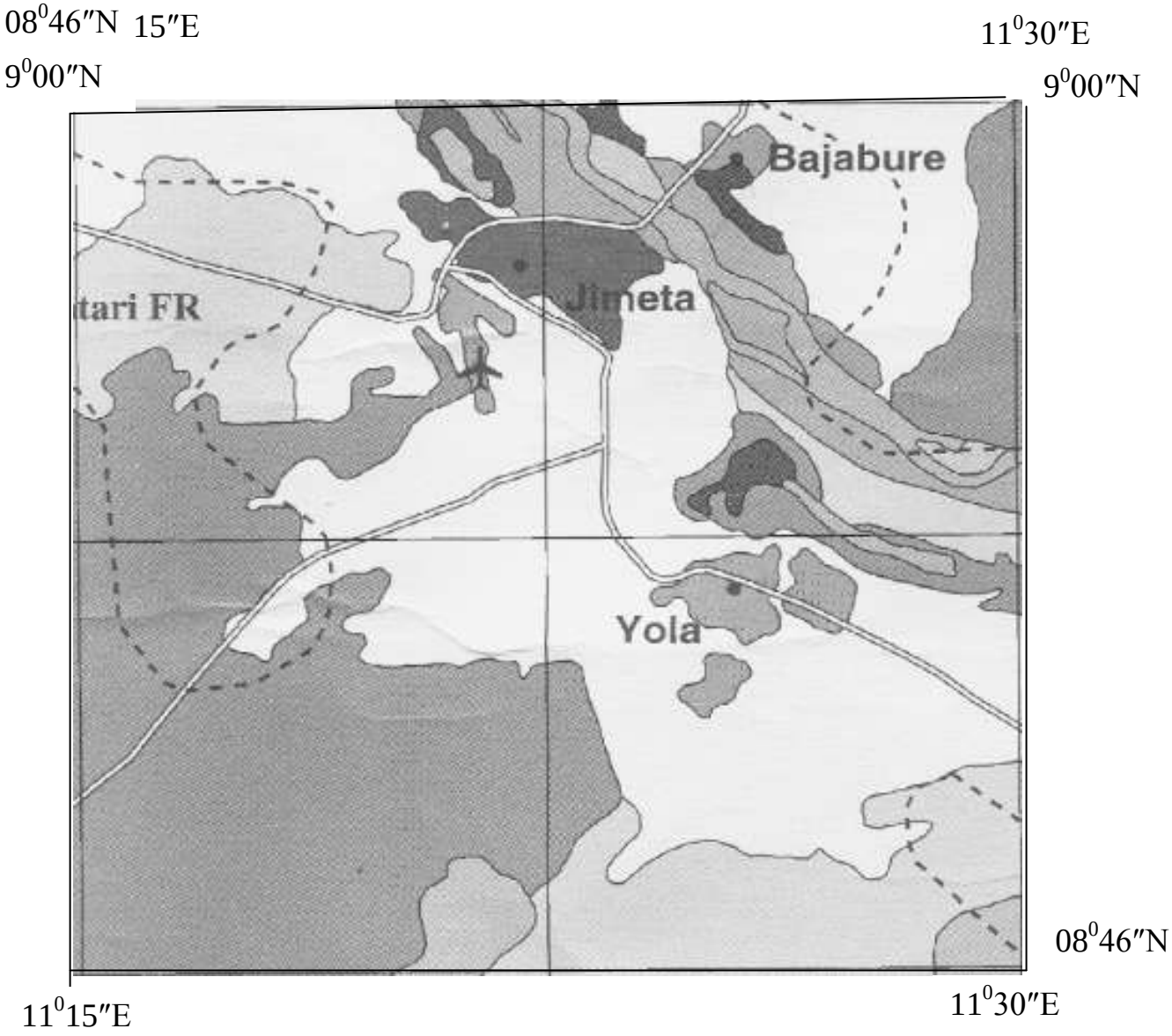
AIMS AND OBJECTIVES OF THE STUDY

The aim of this research work is to model a conducive and favourable area for military barrack in Jalingo, using GIS technique and remotely sensed data.

- To integrate suitability factors such as nearness to road, topography, distance from town and drainage to model suitable and sustainable site for military barracks in Jalingo.
- To detect the areas that meet 80% of the required suitability factors and with a land size of at least 1000 hectares
- To make useful suggestions and recommendation to all the relevant authorities the need to introduce GIS in town planning.

THE STUDY AREA

Jalingo town is situated in Taraba State, and has been the headquarters of Jalingo Local Government since 1976. The town is bounded by Yorro from the north, Ardo-Kola to the south-west, Gongon to the east. Jalingo lies between latitude 8°46″N and 9°00″N and longitude 11°15″E and 11°30″E. It has an approximate population of about 118,000 as revealed by Taraba State Diary (2008). Jalingo has a hot climate with two distinct seasons that is the wet and dry seasons, which exist from April-September and from October-April annually respectively. The mean annual temperature of Jalingo ranges between 35^0 and 38^0 C. It has its cool period within the month of December and January, during this period, temperature could even drop as low as 28^0-30^0c. The major tribes in the area include: Mumuye, Fulani, Wurkum and Kona. Jalingo lies within the Guinea and Sudan Savanna dominated by short grasses and scattered trees within the area (TADP Annual Report 2008). The common agricultural products in the area are: yam, cassava, maize, and groundnut which are produced in large quantities. The area is characterized by gentle slope (undulating flat surface) with mountain ranges at the north-eastern part of the town. (Review of Master Plan of Jalingo Reports 2009).


08⁰46″N 15″E
11⁰30″E
9⁰00″N
9⁰00″N
Bajabure
tari FR
Jimeta
Yola
08⁰46″N
11⁰15″E
11⁰30″E

METHODOLOGY

SOURCES OF DATA

The following data were obtained for the purpose of this research work

Table 1: Sources of Data

S/N	Data Type	Date	Scale	Identification	Acquisition
1	Land-use/ Vegetation map	1995	1:250,000	Sheet 57	FORMECU Abuja
2	Topographical map	1972	1:150,000	Sheet 215	Taraba State Urban Planning

MAP GEOREFERNCING/DATA CAPTURE

The Jalingo land use map of 1995 and the Jalingo topographical map for 1972 were scanned using corel-draw 12 and then exported to Ilwis environment through (TIFF) image file format for georeference. Map georeferncing is very important because it enables all the maps to have the same rows, column, pixel numbers and other reference parameters. A map that is not georeferenced cannot overlay. The coordinates of the four corners of the study areas was transformed to Universal Tranverse Mercartor (UTM) through the transform module of Ilwis 3.0 to create the georeference tie points for both maps. The referenced map was then resampled, using map to map registration with 1995 map as a master map and 1972 map as a slave map into the earlier created georeferenced corner map. Each of the resampled maps was imported to Idirisi, at where the maps were digitized. All the areas feature such as settlements, extensive and intensive agriculture, forest reserve etc. were digitized as polygon, line features such as roads or contours as line and other features such as houses as points.

CRITERIA DEVELOPMENT

Constraints are those criteria that limit suitability to a particular region, that is, it differentiates areas that are considered suitable for Military Barracks from those that cannot be considered suitable under any conditions. In this chapter, two major constraints were set: the **land constraints** and the **water constraints.** Land constraints include the following:

a. Forest Reserve areas: which are considered very important to the environmentalists and on which no any other development is allowed.
b. New development cannot occur on already developed areas, that is, the urban areas such as Jalingo, Mayo Dasa are all considered as constraints.
c. Altitude with higher than 600m above the sea level which may be too costly for development, and may not attract any residential development were selected using the contour lines from the acquired topographical map, which was overlain on the land-use map and digitized.

Using the reclass module of the Idirisi software, each of the above five (5) areas were assigned "0" because they were tagged not suitable, while the remaining land area were assigned the value of "1" that is suitable areas. The output map was called "land constraint". As shown in (Fig.2)

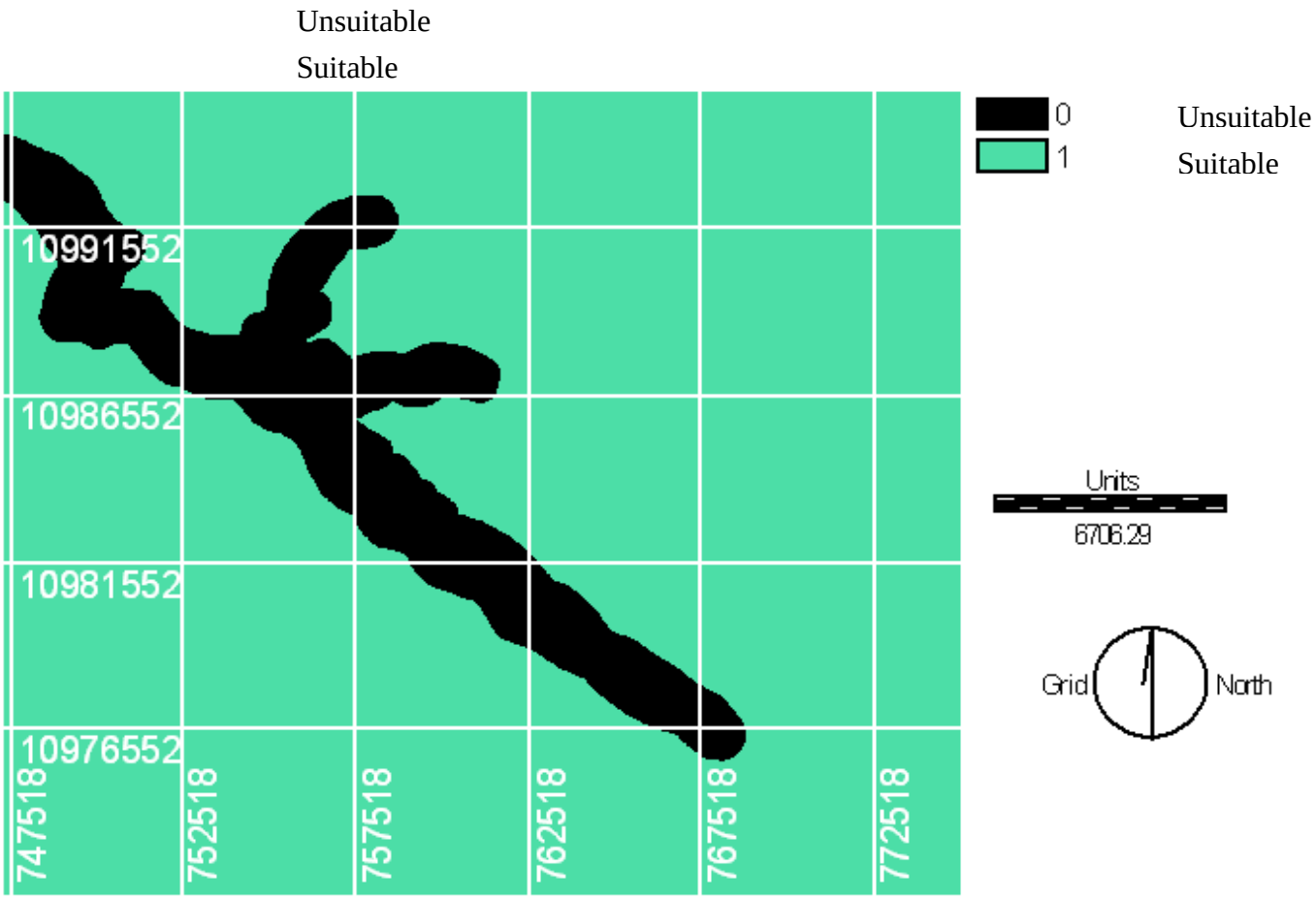


Fig. 2. Land Constraints Areas

Water constraints were also considered.

New development cannot occur within 50m of wetland areas such as marshy lands, floodable areas and swamps. The wetland areas were considered unsuitable and assigned "0", while the remaining areas were considered suitable and assigned "1". The output map is called water constraints as shown in fig. 3

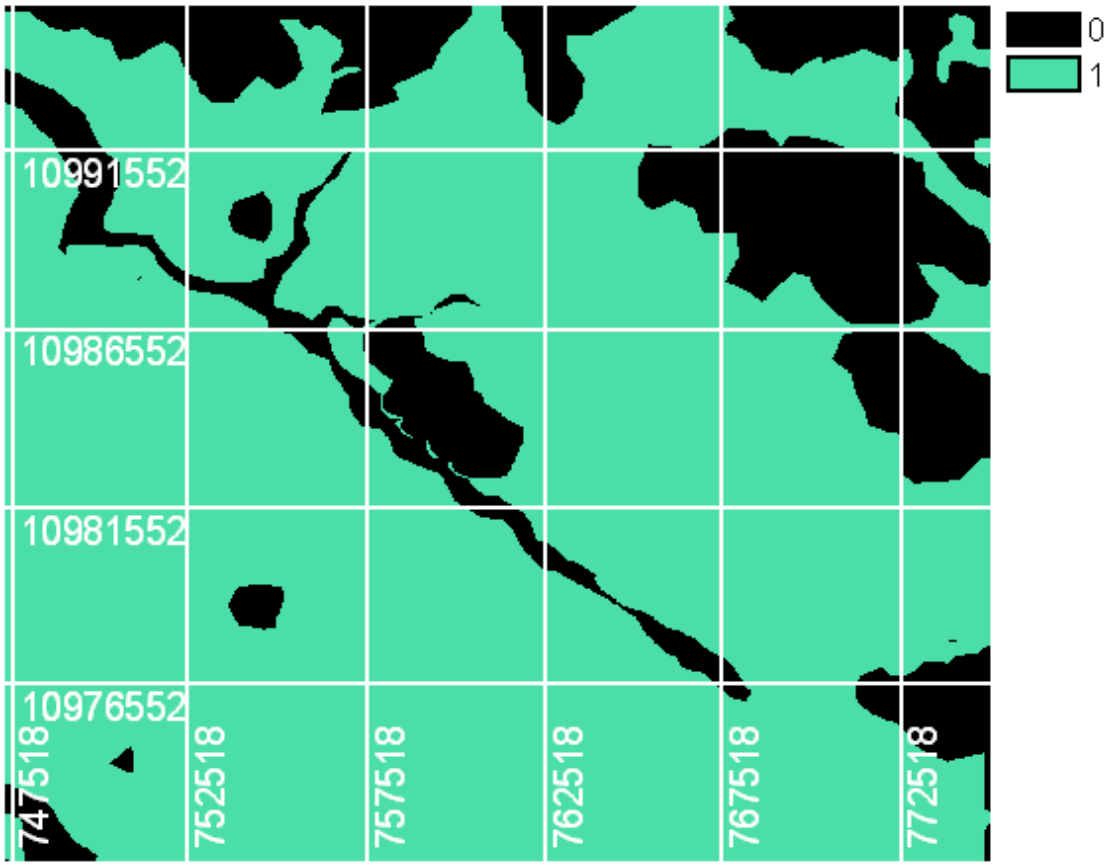
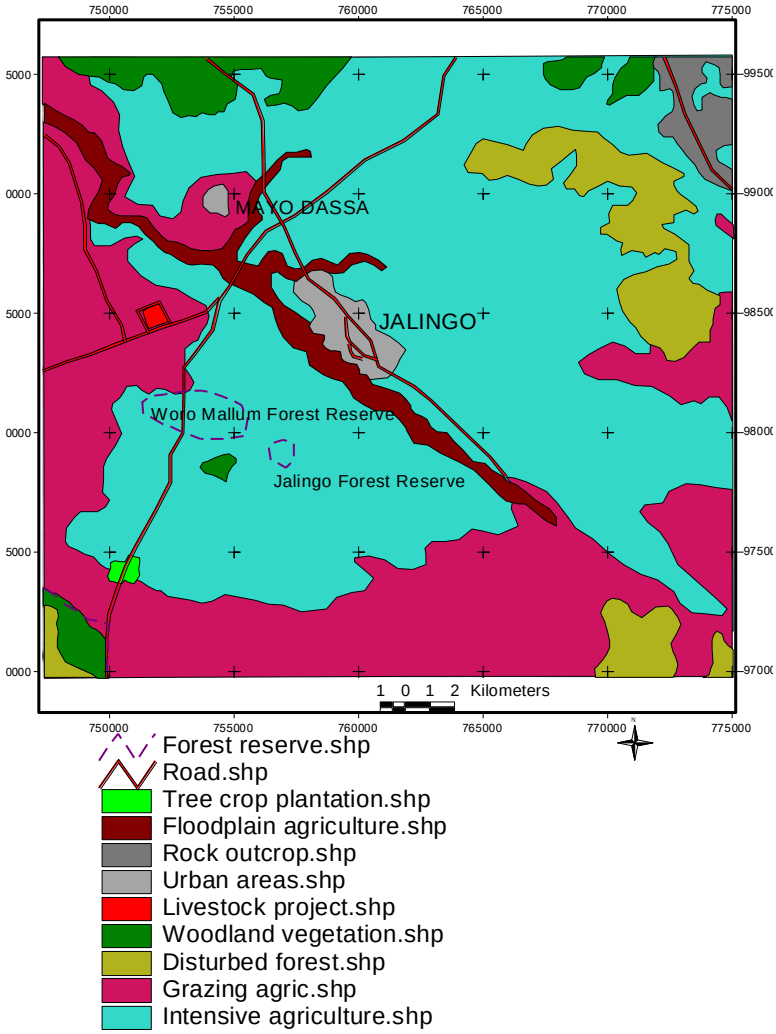


Fig. 3: Water Constraint map

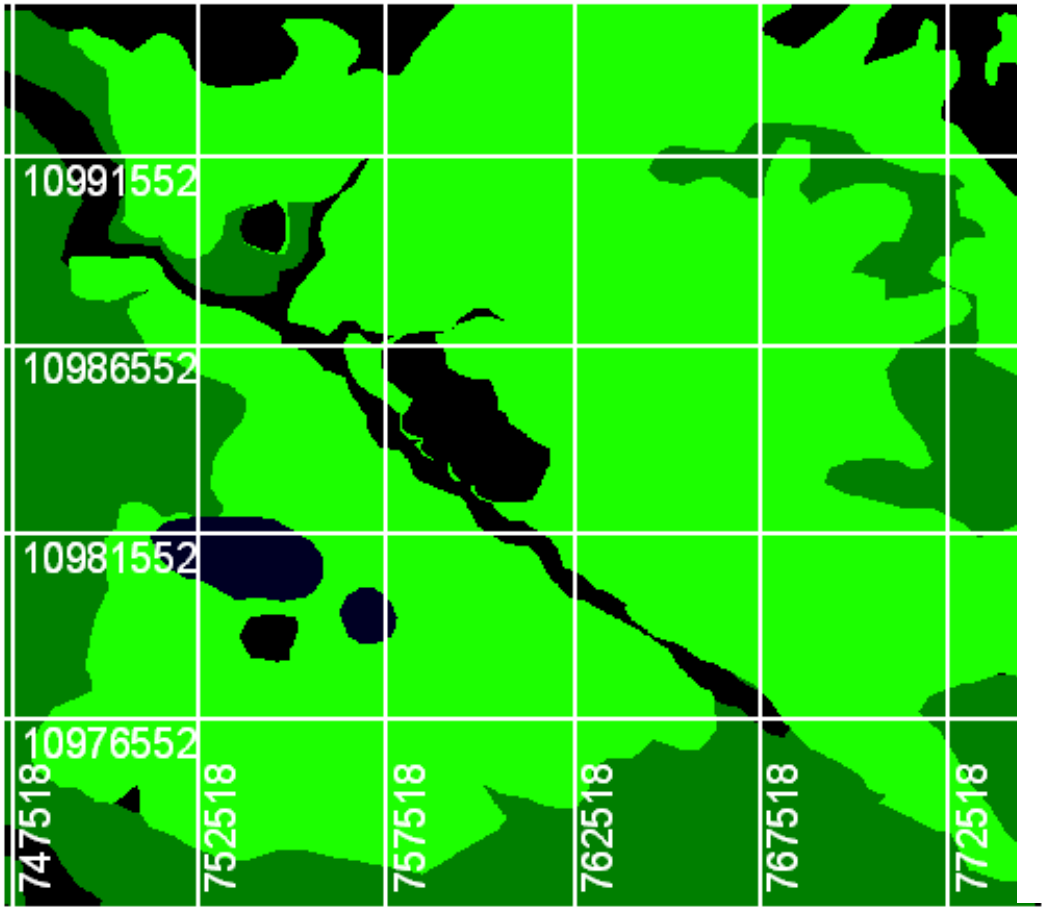
Having determined the constraining criteria, the more challenging process for the planners was to identify the criteria that would determine the relative suitability of the remaining areas. These criteria do not absolutely constraint development, but are factors that enhance relative suitability of an area for residential development.

Four factors were considered in this research work they include:

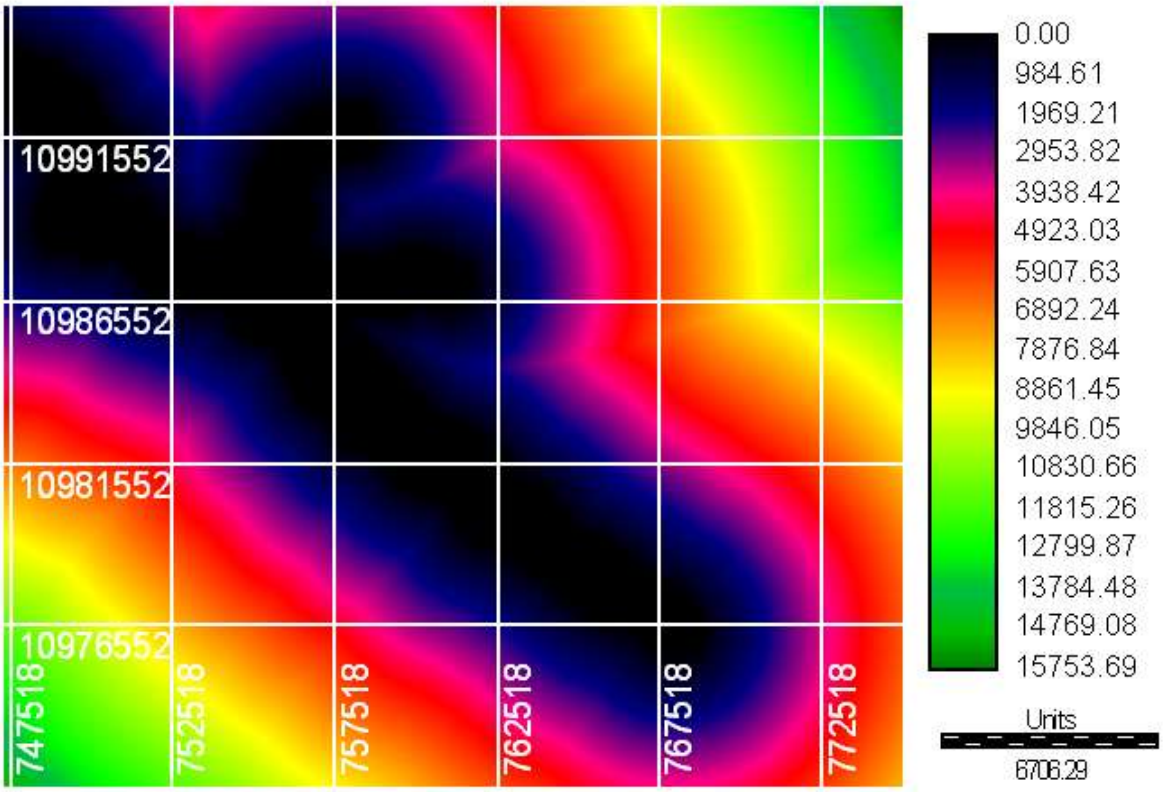
i. **Land use factor:** the land use type available for development was reclassified into suitable and unsuitable types. According to Eastman (2001), there are land use types that are suitable for development; but each has a different level of suitability. On the 1995 land use map of Jalingo, the identifiable land use types were: intensive minor grazing, extensive minor grazing, disturbed forest, agricultural tree, rock outcrop, flood plain agriculture, forest reserve, plantation agriculture, roads and urban as shown in (Fig.4).



The land use map was again digitized in Idirisi environment, and the reclass module was used to give each land use a value within the range of "0" (not suitable), to "255" most suitable; known as standardization of factors to a continuous scale. To this end, on the continuous scale called "fuzzy" a suitability rating of 255 was assigned to extensive grazing areas, disturbed forest was also assigned 255, 200 to intensive agriculture (because they may need compensation), and "0" to all other land use types. Woodland was assigned 0 because of the serious conservation of woodland vegetation programmes in the state.(Fig.5).



ii. Distance to open water factor. Though town regulations as stated earlier acquire residential development to be at least 50m from open water and wetlands, environmentalists prefer to see residential development even further from these water bodies (Eastman 2001). In this example, suitability beyond 50m suitability increase with distance approximately to be 100m. Monotonically, increasing sigmodal function of the fuzzy module of the Idirisi software was used to rescale the values of the total land cover by wetland totaling 16.23 hectares. Hence to accommodate the two thresholds of 100 and 1000 meters in this factor, a value of 100 was input for control "a" and 1000 for control "b". (Fig.6)



iii. Distance to Road: Distance from road is also a continuous factor. Logically developers identified only areas within 400m of roads are suitable and areas within 50m as most suitable, while areas beyond 50m as most suitable, while areas beyond 50m as having a continuously decreasing suitability that approaches, but never reaches "0" which is described by a decreasing J-shape curve. A monotonically decreasing function was chosen from fuzzy of the decision wizard to rescale the distance from roads factor to the J-shape curve. The first control point is the value at which the suitability begins to decline, that is less than 50m, the second control point was set at the value at which suitability is halfway between not suitable and perfectly suitable, that is 400m. The output map is shown figure 7.

iv. **Distance from Developed land factor**: Distance from development land was also rescaled using a linear decay function. Areas closer to currently developed land are considered more suitable than farer areas that suitability is decreasing with distance. The first control point is "0" while the second value would be automatically given whenever linear decay function is used.

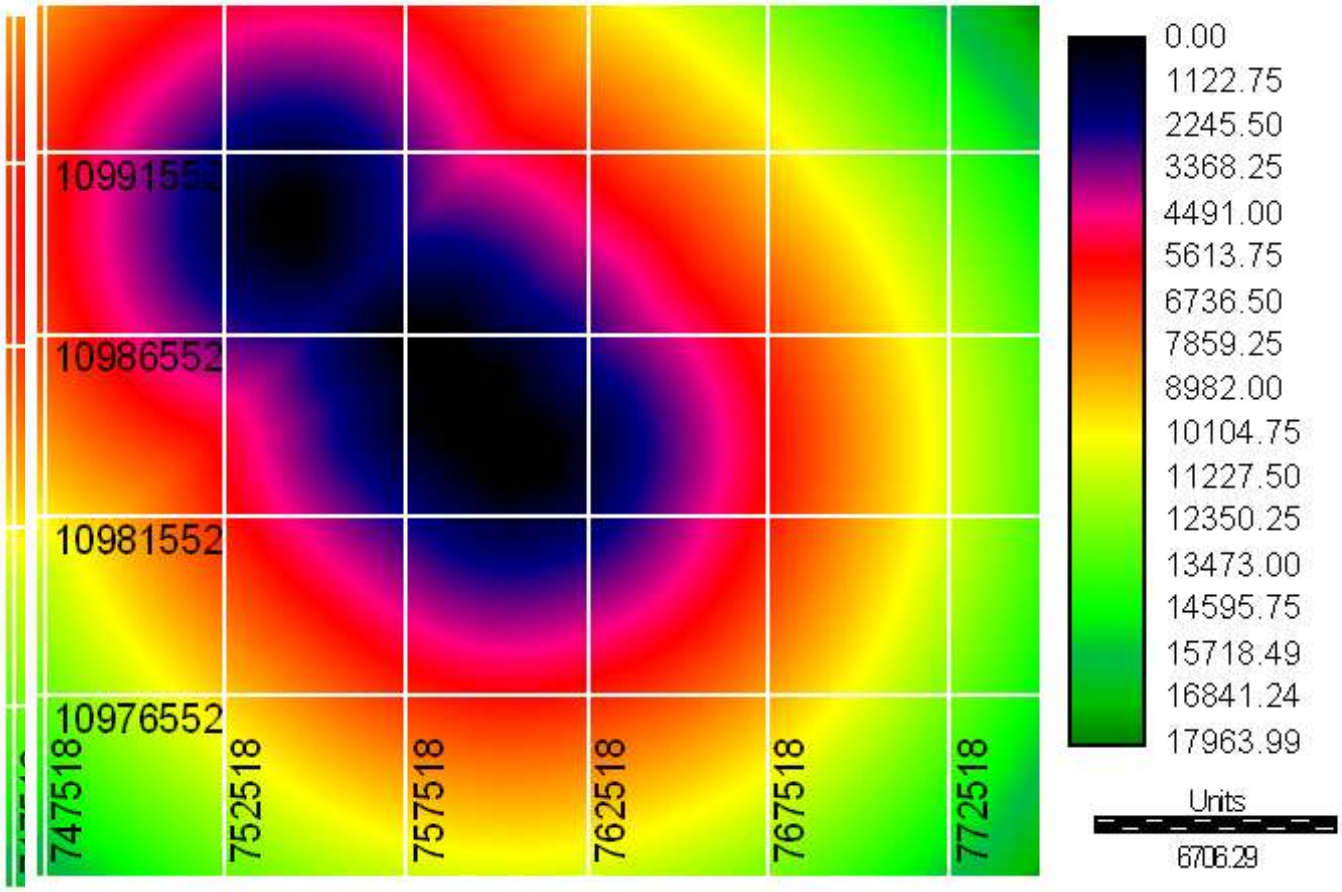
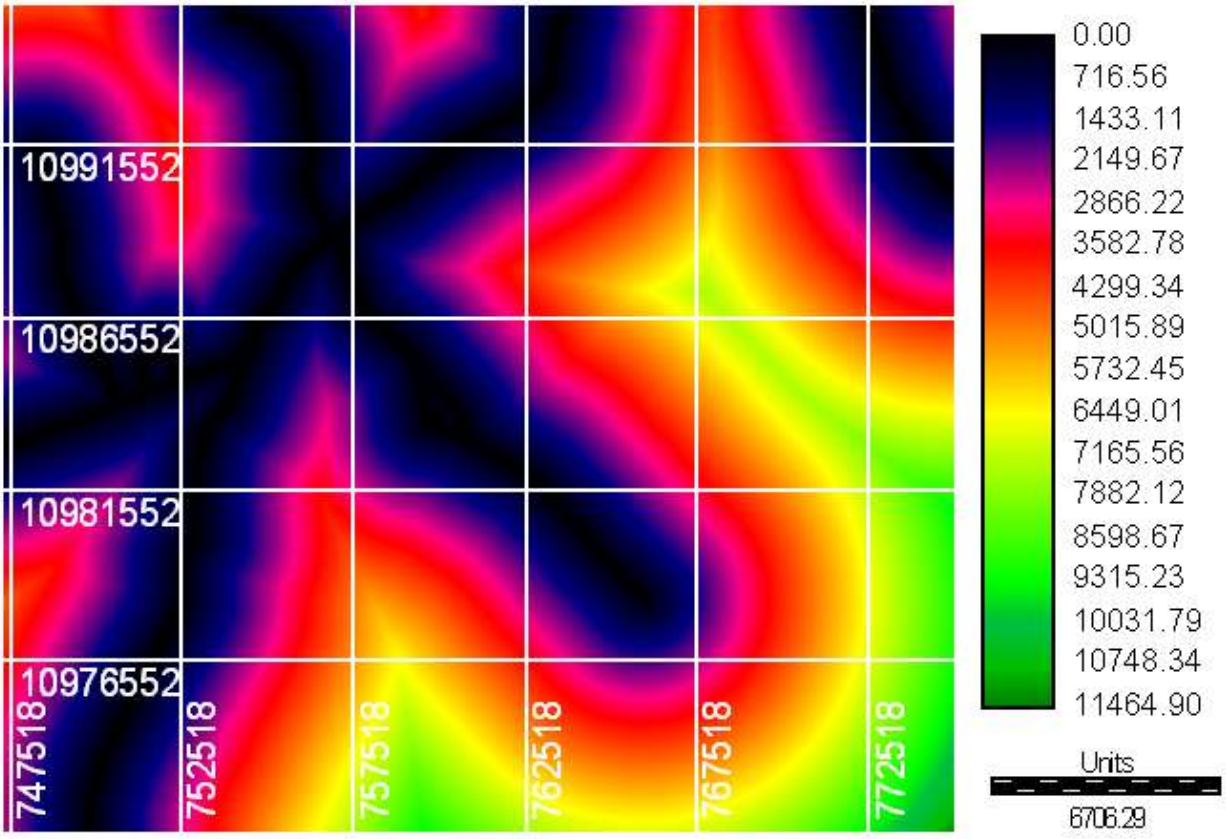


Fig 8: Distance from the Developed Land

All the four factors, having been standardized to the same continuous scale of suitability that is 0-255, fuzzy was run and each standardized factor was automatically displayed as shown in fig 9.



SITE SELECTION USING SUITABILITY IMAGES.

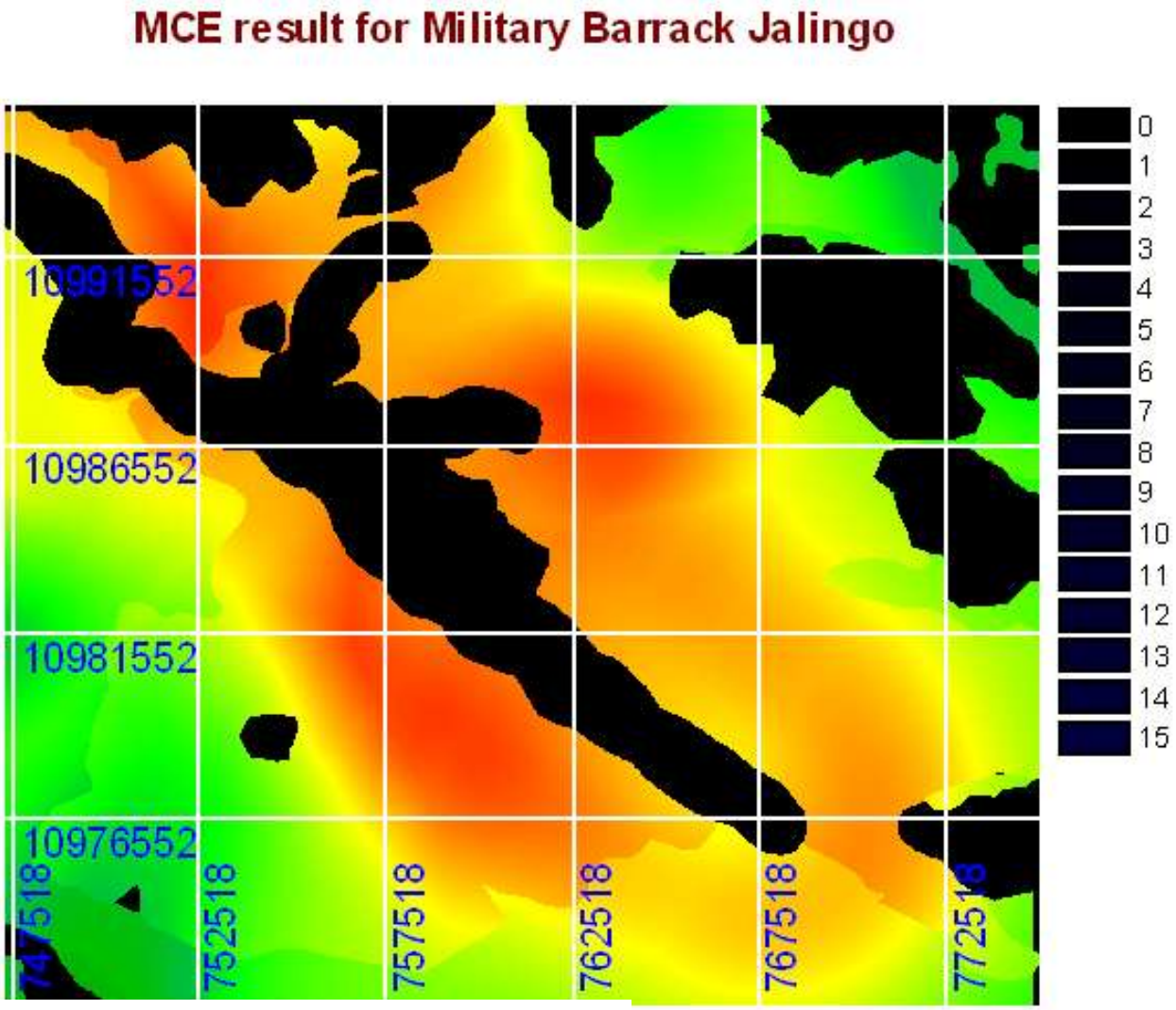


Fig 9: MCE Result of the WLC Criteria

There are several methods that can be adopted for site selection using continuous image of suitability, in this research work, suitability thresholds was used. In this method, a level of suitability is specified as a threshold for considering a location that is finally suitable or not. In this method, it is not the degree of suitability but the total quantity of land for selection that determines a threshold. For this work, as already been stated that suitability areas must meet minimum of at least 1000 hectares and 85% of the set conditions (that is, 85% of 255, which is 216), this means that the parameters used in selecting the suitability site must meet equal to or greater than 216, and more than 1000 hectares as shown in Fig.10 where only site 7 meet the two conditions.

When a minimum of 216 scores out of the maximum 255, and minimum of 1000 hectares of land was applied, only Alkali Yabba area was discovered to have met the two conditions.

Hence, the area was selected to be the best site. This area was zoomed for proper viewing, arrowed and labeled military 216 as shown in fig. 11.

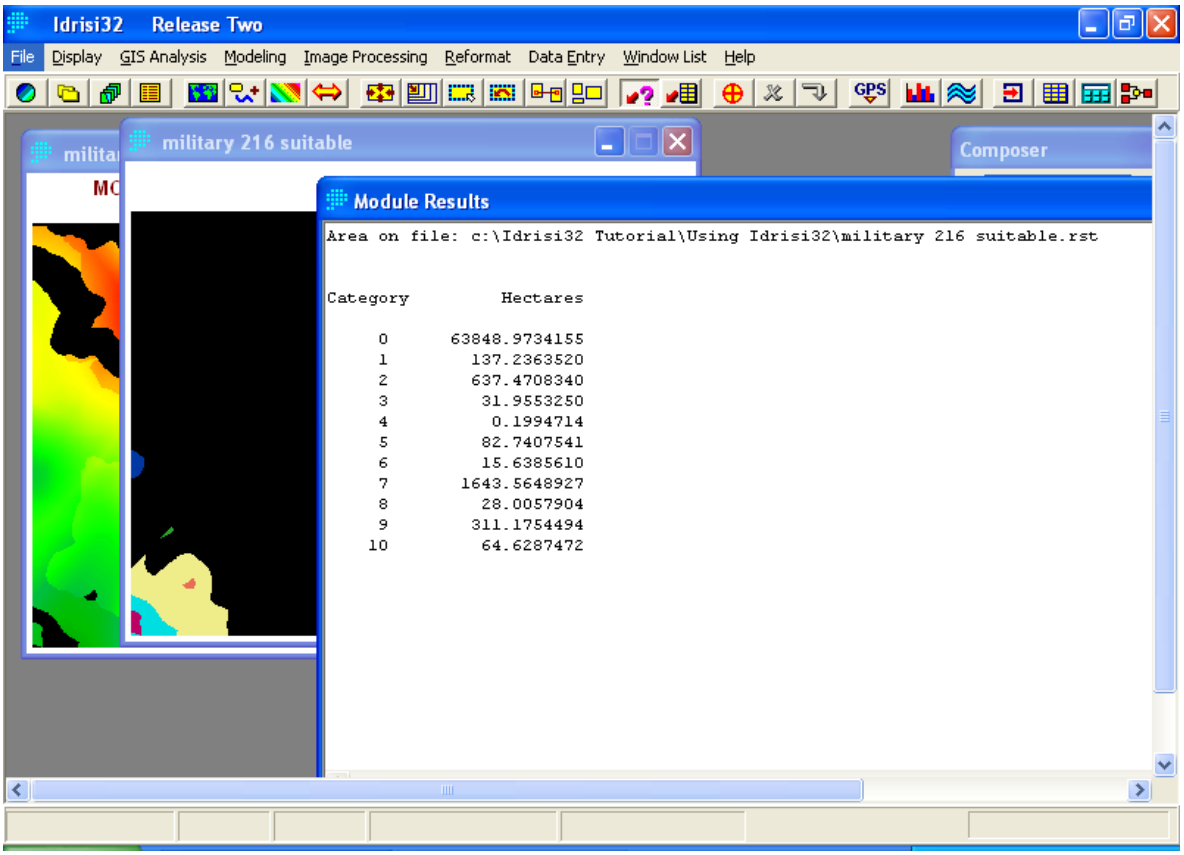


Fig 10: Areas with minimum of 216 scores and 1000 hectares size

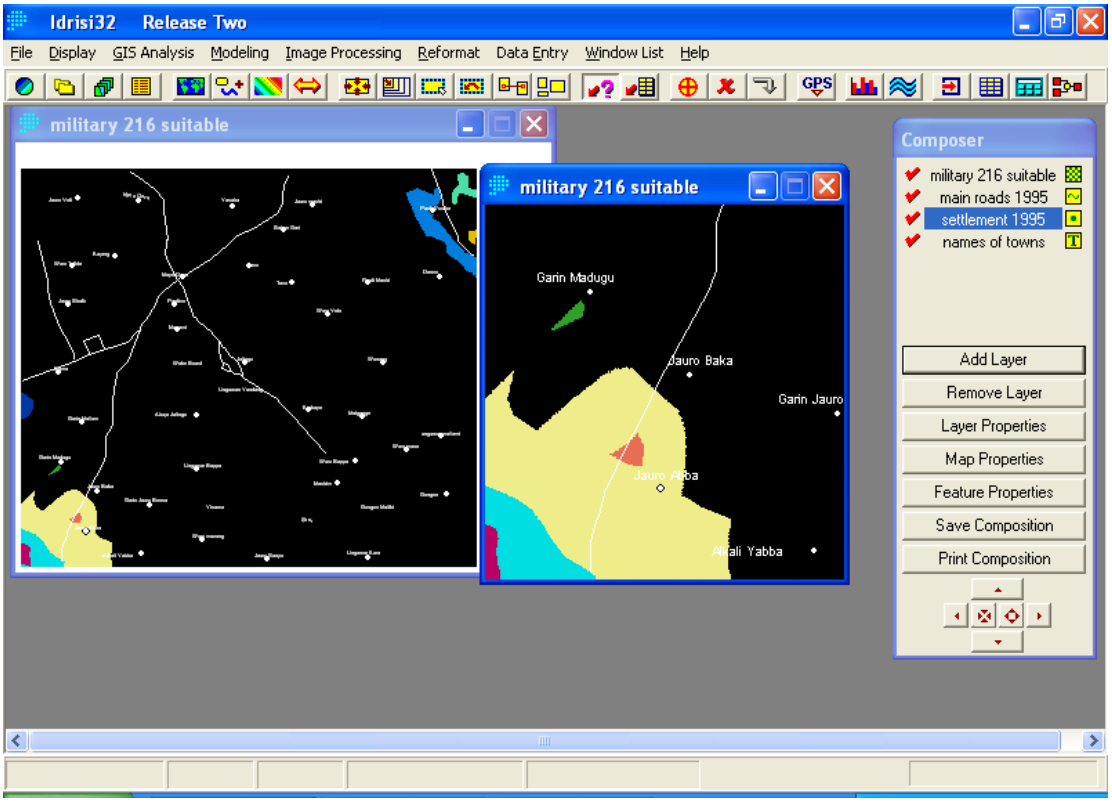


Figure 11

RESULTS AND DISCUSSION

An admirable method of standardization was introduced in which factors are not just use to determine the constraint of "suitability" that is areas that meet all the necessary conditions for military barrack and "not suitable" which does not meet all the conditions. The factors were standardized to a scale of "0" (least suitable) and 255 (most suitable). The method is considered to be reliable, time saving and most of all, flexible. It can easily be manipulated to derive desire results. For instance planners may use different factors or combination of factors; or may even simply relax either or both of the post aggregation constraints. Hence, analysis and findings can be simply summarized as follows:

- that the suitable site for Military Barracks in Jalingo is located in the south-eastern part of Jalingo town around Alkali Yabba settlement. (Fig11)
- this detected suitability site is connected by the major road from Jalingo town to Alkali Yabba. (Fig.11)
- the total suitable site/area was calculated to be "1643.54" hectares of land which has met all the necessary conditions. (Fig.10)
- the distance of the suitable site from Jalingo was calculated to be 6.5kilometers.

SUMMARY AND RECOMMENDATION

The use of GIS technique and remotely sensed data for site suitability for Military Barrack development using Weighted Linear Combination (WLC) has been demonstrated in this research work. Looking at the contribution of GIS as shown in this paper, one may conclude

that it may be a difficult task if traditional methods like land survey, or field works were used, taking into consideration the vast terrain of Jalingo and the available resources and infrastructure. Hence, GIS has made it easier to detect, select, and analyze all the constraints that may arise at the cause of this project. Therefore, town planners should be encouraged to use the techniques in their day to day activities. Relevant data should be made available to individuals, groups and society for town planning. Training and re-training of staff such as town planners, engineers, architects etc on the field of GIS technique and relevant application software should be given more priority especially now that the world is fast becoming a global village. Settlements that fall within the suitable site should be compensated or relocated to another area by the government to prevent displacement of people in the area especially Alkali Yabba the main settlement in the suitable site. (Fig.11)

CONCLUSION

The methods of Non-Boolean Standardization and Weighted Linear Combination have been demonstrated in this paper. In this method, factors were not just reduced to the popular simple Boolean constraints of "suitable" and "not suitable", but instead the factors were standardized to a continuous scale from 0 (least suitable) and 255 (most suitable). It can also be easily manipulated to derive desired results. For instance, town planners may use different factors or combination of factors, they might alter the original methods/ functions used for standardization of factors, they might weight factors differently, or they may even simply relax either or both of the post-aggregation constraints.

Urban planners, Ministry of Environment, Federal Environmental Protection Agencies and other stake holders should ensure proper planning of our cities with reliable and up-to-date data which only GIS and remote sensing technique is the only technology that can provide such data. The state government should look inward to the identified suitable area for military barrack site, so as to make the sites environmentally free from human destruction. Future researchers may explore current data. The identified sites can further be verified using any convenient methods of ground truth.

REFERNCES

Burrough, A. (1986). Application of Satellite and GIS Technologies*. Land- Cover and Land use Mapping at the Rural-Urban Fridge.* (ed.T. Banerjee), MIT Press, Cambridge, MA, pp. 439-448.

Eastman, J.R. (2001). *Idrisi32 Release 2 Tutorials.* Clark University USA

Flora, S. (2004). Application of Spot Data for Regional Growth Analysis and Local Planning. *Photogrammetric Engineering and Remote Sensing,* 5th Edition. Oxford University Press, New York. pp.175-180.

Florent, P. (2001). The Timeless Way of Building*, Nature of Housing.* Oxford University Press, New York. pp 25-27

Johnson, N. (1992): Application of Remote Sensing and GIS. The Integration of Geographic Data with Remotely Sensed Imagery to Improve Classification in Urban Area. *International Journal on Remote Sensing pp. 253-278*

McSherry, J. (2000) A Theory of Good City*, The Openness of Open Space, in City Sense and City Design.* MIT Press, Cambridge, M.A. pp. 243.245

Mitchell, S. (2005): The ESRI Guide to GIS Analysis*: Spatial Analysis and Statistics.* New York: ESRI Press. pp. 45-53

Pesaresi, N. (2001): Survey for Planning in Town and Country Planning. *Pattern of Metropolitan Development*. New York Standard Press. pp. 125-130

Richards, P. (1994): Remote Sensing and GIS Image Interpretation. *Viewing the Earth from Space.* 4th edition, New York, pp. 993-998.

Review of Master Plan of Jalingo Reports. (2009).

Taraba Agricultural Development Programme (TADP) (Annual Report 2008).

Taraba State Diary (2008).